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# MYCOLOGIA

OFFICIAL ORGAN OF THE MYCOLOGICAL SOCIETY OF AMERICA

VOL. XXXI JANUARY-FEBRUARY, 1939

No. 1

## NEW AND NOTEWORTHY GASTEROMYCETES<sup>1</sup>

S. M. ZELLER

(WITH 54 FIGURES)

This paper is based for the most part on hypogeous Gasteromycetes from the Pacific Northwest and specimens in the Farlow Herbarium, Harvard University. The last several seasons have been favorable for the collection of hypogeous fungi (both Ascomycetes and Basidiomycetes) in western Oregon and Washington. In 1937 the writer alone or in company with botanical colleagues procured 152 collections of hypogeous Gasteromycetes in Oregon.

The specimens from the Farlow Herbarium were kindly loaned by Dr. D. H. Linder or Dr. G. D. Darker. Among them were several collections taken by the late Dr. R. Thaxter in the United States and South America, and which add materially to our knowledge of the Hysterangiales.

It has been the desire to present at one time illustrations of spores of the various species of *Melanogaster*. Therefore outline drawings of 12 species have been included to fill out unoccupied space in the plates.

I want to express thanks to Mrs. D. P. Rogers for her careful work in illustrating the paper, and to Dr. D. P. Rogers for critically editing the Latin diagnoses.

<sup>1</sup> Published as Technical Paper No. 291, with the approval of the Director of the Oregon Agricultural Experiment Station. Contribution from the Department of Botany.

Each species will be discussed separately except where new genera and families are involved, in which cases several species or genera may be treated in groups.

### 1. *Rhizopogon exiguus* sp. nov.

Fructifications 2-10 mm. crassae, globosae vel irregulares, spongiosae, superficie laevi, albae, cum maculis ochraceis, dein rubescentibus vel "snuff-brown"; fibrillis supra paucis, infra radiceformibus; peridio 200-400  $\mu$  crasso, hyphis magnis, hyalinis; gleba alba dein brunnea, siccitate "raw umber"; locellis subglobosis, parvis, maturitate sporis partim repletis; septa 60-70  $\mu$  crassis, hyphis magnis, hyalinis, contextis; basidiis tetrasporis, cylindriceis, 14-20  $\times$  3-5  $\mu$ ; sporis brunneis, ellipsoideis, 7-8  $\times$  5-5.5  $\mu$ ; odore farinaceo.

Sub foliis in pinetis, St. Washington, Am. bor.

Fructifications small, 2-10 mm. in diam., globose to irregularly lobed, soft, spongy, surface smooth, white with ochraceous mottling, becoming snuff-brown; fibrils scanty above, rhizomorphic below; peridium simple, 200-400  $\mu$  thick, of coarse hyaline hyphae, the outer part oxidized darker; gleba white then brown (drying raw umber); cavities small, rounded, partly filled with spores (FIG. 14); septa 60-70  $\mu$  broad, including the hymenia, of large hyaline hyphae; basidia 4-spored, cylindrical, exceeding the paraphyses about 7  $\mu$ , 14-20  $\times$  3-5  $\mu$ ; spores brown, ellipsoid, 7-8  $\times$  5.5  $\mu$  (FIG. 15); odor farinaceous.

In heavy duff, among mycorrhizal roots of hemlock. August.  
The habitat of *R. exiguus* is similar to that of *R. parasiticus*.

#### SPECIMENS EXAMINED:

Washington: Pierce County, Silver Springs Recreational Area, S. M. Zeller, 8278, type, Aug. 18, 1937; Yakima County, east side of Natches Pass, Mt. Rainier Forest Reserve, D. E. Stuntz, Aug. 20, 1937 (in Zeller Herb., 8279).

### 2. *RHIZOPOGON ROSEOLUS* (Corda) Zeller & Dodge.

In the Herbarium of the Department of Plant Pathology, University of Wisconsin, there is a collection of this species under the name "*Rhizopogon roseus* Bresadola n. sp." This was collected by Dr. B. O. Dodge, "opposite Stand Rock, Kilburn, Dells of the Wisconsin, Aug. 1905 (Fide Bresadola)." The material is unmistakably *R. roseolus*. It perhaps will be necessary to disregard Bresadola's name in the synonyms for *R. roseolus*, since

another collection (5914 in Lloyd Collections) under the same name is referable to *R. Vittadinii* (Tul.) Zeller, comb. nov. (*R. rubescens* var. *Vittadinii* Tul.).

Some have expressed the opinion that material referred to this species is merely a very mature stage of another species like *R. rubescens* because of the gelified condition of the vesiculose paraphyses (Coker & Couch, *Gasteromycetes of East. U. S. pl. 107, f. 12, 13*) and hyphae. A collection from Prof. James McMurphy taken at Governor's Camp, Big Basin, California (no. 302), is very young and without spores but the paraphyses are heavily gelatinized.

Three collections by D. H. Linder and R. F. Smart from Richmond, Va., are quite typical.

### 3. *Rhizopogon separabilis* sp. nov.

Fructificationes subsphaericae, lobulatae, 1.5–4 cm. crassae, glabrae, albae vel "cartridge buff," cum maculis "vinaceous pink," dein "cream buff," siccatae fuscae; fibrillis paucis vel numerosis; peridio simplici, facile a glebo separabili, 425–550  $\mu$ , crasso, prosenchymato lento hyalino, siccato fragili; gleba alba, dein "buffy citrine" quando lecta, siccata "isabella color"; locellis parvulis, irregularibus; septis hyalinis, prosenchymatis cum hyphis laxis scissilibusque ad angulos, 15–26  $\mu$ , crassis inter hymenia; basidiis 4–6-sporis, cylindraceutis, 8–11  $\times$  3.5–5  $\mu$ ; sterigmatibus 4–6  $\mu$  longis; sporis 2-guttulatis, inaequilateraliter ellipsoideis, singulatim hyalinis, 5–7  $\times$  1.5–2.5  $\mu$ ; odore grato farinaceo vel ei *Solani tuberosi* simili.

In terra arenosa sub *Pino contorta*, prope oceanum, Oregon, Amer. bor.

Fructifications subspherical, somewhat lobed, 1.5–4 cm. in diam.; surface rather smooth, traversed by few or many fibrils, white to cartridge buff with vinaceous pink spots, becoming "cream-buff," changing to russet where bruised, drying fuscous; peridium simple, easily breaking (shell-like) from the gleba when fresh, vinaceous tawny where cracked, 425–550  $\mu$  thick, of tough, hyaline, prosenchymatous strands plaited together, drying brittle after separation (FIG. 17); gleba white, then buffy citrine when fresh, drying isabella color; cavities rather small, irregular; septa hyaline, mostly prosenchymatous but sometimes of loose hyphae at the angles, then scissile there, 15–26  $\mu$  broad between hymenia; basidia 4–6-spored, cylindrical, 8–11  $\times$  3.5–5  $\mu$ ; sterigmata nearly as long as the spores; spores mostly 2-guttulate, with nucleus equatorially placed (as in spores of *R. roseolus*), ellipsoid, hyaline when alone, 5–7  $\times$  1.5–2.5  $\mu$  (FIG. 18); odor pleasantly farinaceous or earthy, like potatoes.



In sand under *Pinus contorta* along coast, Florence to Waldport, Oregon. July and November.

The peridium as in *R. atlanticus* is easily separable and in mature specimens it is irregularly dehiscent, exposing the gleba (FIG. 11). The peridium is tough, becoming shell-like when dry. It differs from *R. atlanticus* in the structure of the peridium and trama, and size of spores.

SPECIMENS EXAMINED:

Oregon: Lane County, Florence, *A. H. Smith, A. B. Hatch,* and *S. M. Zeller*, Nov. 22, 1935, type, Zeller no. 8236. Sutton Lake, *Dr. and Mrs. D. P. Rogers* no. 415, 451, Nov. 26, 1937; Lincoln County, Waldport, *S. M. Zeller*, 8176, July 3, 1936.

4. *Rhizopogon Thaxteri* sp. nov.

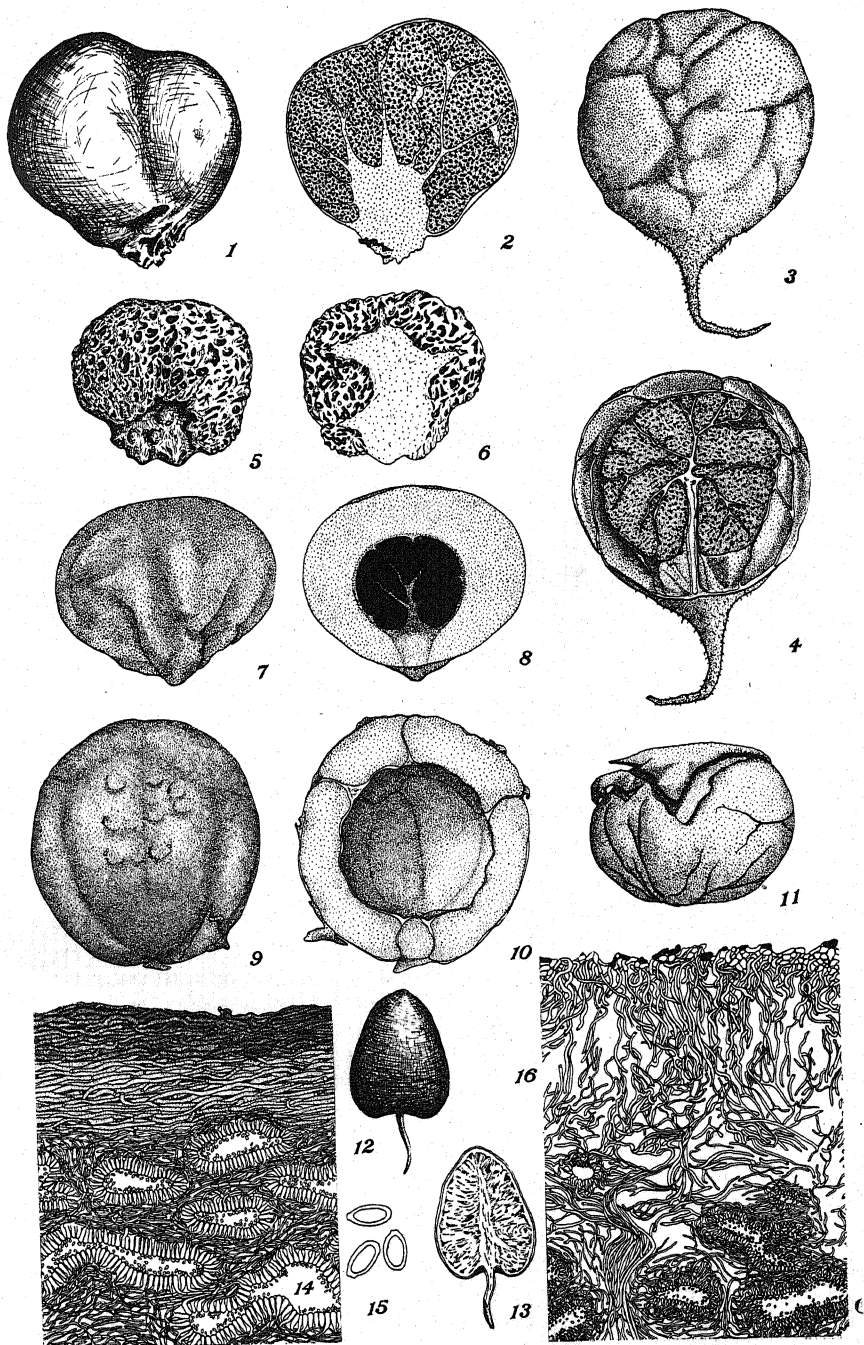
Fructificationes subglobosae, 1 cm. latae, sordide albae tactu rubescentes, dein "carob brown" vel "chestnut brown"; fibrillis paucis, liberis sed ad superficiem inferiorem stipposim applanatis; peridio 600–700  $\mu$  crasso lento simplici, hyphis hyalinis vel flavidis magnis circa 5–6  $\mu$  crassis composito; gleba sordide olivacea, quando lecta, fusca conservata; locellis subglobosis, vacuis; septis 60–70  $\mu$  crassis, scissilibus, hyphis hyalinis contextis; basidiis cylindraceis, circa  $18 \times 4 \mu$ ; sporis subsessilibus, cylindraceis, supra rotundatis, infra cicatricula sterigmatica ornatis, subhyalinis,  $6-8 \times 1.5-2 \mu$ .

Sub *Pino Strobo*, prope Kittery, Maine, Am. bor. (*R. Thaxter*).

Fructifications subglobose, 1 cm. in diameter, dirty-white, staining reddish when fresh, becoming carob-brown to chestnut-brown; fibrils scanty, free but flattened against the lower side, giving a general felty appearance to the surface; peridium 600–700  $\mu$  thick, tough, of one layer of large, thin-walled, hyaline or yellowish hyphae about 5–6  $\mu$  in diam. (FIG. 28); gleba dirty-olive when fresh, dark-brown in preservative; cavities subglobose to irregular, empty; septa 60–70  $\mu$  (30–35  $\mu$  between the hymenia), of loosely woven hyphae, scissile, hyaline; basidia cylindrical, about  $18 \times 4 \mu$ ; spores almost sessile, cylindrical with rounded distal end and sterigmatic scar at base, subhyaline,  $6-8 \times 1.5-2 \mu$  (FIG. 29).

Under *Pinus Strobus*, Riley Place, Kittery, Maine, *R. Thaxter* (1902 y), type (in Farlow Herb. Harvard Univ., Thaxter Bequest, no. 6384).

The spores in this species have the nucleus equatorially placed, appearing somewhat like a septum, as in *R. roseolus*, but the spores are much narrower and sessile or almost so. It is related to



FIGS. 1-16.

*Rhizopogon Vittadini* (Tul.) Zeller, but the peridium is thicker, is composed of much larger hyphae, has a distinct red pigment in the oxidized outer layers of the peridium, and also differs in the spore characters mentioned above.

### TRUNCOCOLUMELLA gen. nov.

Fructificationes depresso-sphaeroidae vel reniformes, basi rhizomorphicos, sterili instructae; columella truncoidea vel dendroidea et prominens; peridium persistens, indehiscens vel non separabile vel evanidum; gleba brunnea; sporis levis, ellipsoideis, coloratis, singulatim hyalinis (ut in *Rhizopogonis*).

Fructifications depressed-spheroid to reniform, from a rhizomorphic base; *columella* stump-like to dendroid, prominent; *peridium* persistent, indehiscent, not separating from the gleba, but sometimes early evanescent; gleba brown; spores smooth ellipsoid, colored but almost hyaline when alone (as in *Rhizopogon*).

This genus has spores and glebal structure like those of *Rhizopogon* but the stout, branched columella is the distinguishing character to separate it from that genus (FIG. 2, 6). It has some relationship therefore with *Dendrogaster* and *Hysterangium* but does not have the gelatinous-cartilaginous glebal tissues as in the latter.

The type species is:

#### 5. *Truncocolumella citrina* sp. nov.

Fructificationes depresso-globosae vel reniformes vel cordatae, 2.5–4 cm. crass., 1.6–4 cm. alt.; superficie deorsum laevi, superne leniter rimoso-areolata, citrina, inquinata crenea vel "old gold" siccata; columella truncoidea vel dendroidea, supra lamellis alboluteis prominentibus composita, hyphis 4–7  $\mu$  crass., byssoideis contexta, basi rhizomorphico citrina instructa; peridio 70–100  $\mu$  crass., hyalino, ad superficiem; hyphis citrinis radialibus tecta, gleba "honey yellow," "tawny-olive" siccata; septis 50–60  $\mu$  crass., hyphis magnis laxe implexis; basidiis cylindraceutis bi-vel tetrasporis 17–20  $\times$  4–5  $\mu$ , sterigmatibus brevibus; sporis ellipsoideis, uniguttulatis, leniter brunneolis, sub lente subhyalinis 6–10  $\times$  3.5–5  $\mu$ ; odore grato.

Fructifications depressed-globose to reniform or cordate, 2.5–4 cm. broad, 1.6–4 cm. high; surface glossy smooth below, dull and sometimes cracked-areolate above, whitish then citrine yellow, drying sordid cream color to old gold where bruised; *columella* stump-like or dendroid, the base and branches of yellowish-white tissue, composed of large, loose-meshed hyphae, 4–7  $\mu$  in diam.; sterile base merely the broad base of the *columella*, citrine yellow,

usually from a large yellow rhizomorph; peridium 70–100  $\mu$  thick, of interwoven hyphae which are citrine-colored near the surface and hyaline below, in young specimens the superficial hyphae are most often radial (FIG. 16); gleba honey-yellow drying tawny-olive; septa 50–60  $\mu$  between hymenia, of loose, large, almost parallel hyphae; basidia cylindrical, 2–4-spored,  $17\text{--}20 \times 4\text{--}5 \mu$ ; sterigmata about  $\frac{1}{2}$  the length of the spores; spores ellipsoid, 1-guttulate, brownish in mass, almost hyaline under the scope,  $6\text{--}10 \times 3.5\text{--}5 \mu$  (FIG. 23); odor pleasant.

Under forest duff or emergent, under conifers. Clackamas, Douglas, and Linn Counties, Oregon, King County and Mt. Rainier National Park, Washington, and Humboldt County, California. August to November.

This species has proven to be one of the most common of the hypogeous fungi in coniferous forests of the Pacific Northwest. The type collection includes 23 fructifications and another large collection comes from D. E. Stuntz, Seattle. Very mature specimens deliquesce in a manner similar to *Rhizopogon*.

SPECIMENS EXAMINED:

Washington: King County, Seattle, *D. E. Stuntz*, Oct. 18, 1937; Pierce County, Frying Pan Creek, Mt. Rainier National Park, *D. E. Stuntz*, Aug. 20, 1937.

Oregon: Clackamas County, about 100 yards up Paradise Park Trail from Twin Bridges Forest Camp, *S. M. Zeller*, 8229, Sept. 3, 1935; Douglas County, Comstock, *S. M. Zeller*, 8320, type, Oct. 20, 1937, 8401, Oct. 23, 1937, and *H. M. Gilkey*, *A. M.* and *D. P. Rogers*, and *S. M. Zeller*, 8363, 8387, 8389, Nov. 6, 1937; Linn County, 5 miles S.E. of Lebanon, *G. S. Burlingham*, Nov. 5, 1934 (in *Zeller Herb.*, 8213).

California: Humboldt County, Spruce Cove, Trinidad, *H. E. Parks*, 4120, Nov. 20, 1932, 4623, Nov. 1933, and 4624, Sept. 1933 (in *Parks Herb.* and *Zeller Herb.*).

6. *Truncocolumella rubra* sp. nov.

Fructificationes piriformes, 2–3.5 cm. crassae, 2.5–3 cm. altae; peridio tenui, mox fere omnino evanido, hyphis infra hyalinis ext. rubidis; gleba sordide luteola, tactu in colore livido mutabili, siccitate umbrina, superficie nuda badia vel rubro-brunnea, solo tecta "aniline yellow"; locellis magnis labyrinthiformibus; columella 7–12 mm. crassa, subpercurrenti, cum ramis

tenuibus a latere apiceque radiantibus, a basi sterili non distincta, intus flavido-alba, tactu in colore livido mutabili, siccitate sordide flavida; septis circa  $100\mu$  crassis, hyphis hyalinis implexis; basidiis 4-sporis, cylindraceis,  $11-13 \times 5-6\mu$ ; sporis oblongo-ellipsoideis, ochraceo-brunneis,  $10-12.5 \times 4.5-5.5\mu$ .

Fructifications broadly pyriform, 2-3.5 cm. broad, 2.5-3 cm. high; peridium thin, almost entirely evanescent at maturity, composed of parallel hyphae, hyaline within, reddish on surface; gleba sordid light-yellow, changing bluish on bruising or exposure, drying raw umber; surface exposed by the early dehiscence of the peridium (FIG. 5), bay to brighter reddish-brown above, aniline-yellow where covered by soil; cavities relatively large, labyrinthiform (FIG. 21); columella stout, 7-12 mm. broad, almost percurrent, with narrow branches radiating laterally and terminally (FIG. 6), extended below as a sterile base, yellowish-white within, changing bluish when bruised or exposed, drying sordid yellowish; septa about  $100\mu$  thick, composed of hyaline, intertwined hyphae; basidia 4-spored, cylindrical,  $11-13 \times 5-6\mu$ ; spores oblong-ellipsoid, ochraceous-brown,  $10-12.5 \times 4.5-5.5\mu$  (FIG. 22).

Emergent from heavy duff under hemlock, near Snoqualmie Pass, King County, Washington, D. E. Stuntz, Aug. 19, 1937, type (in Zeller Herb. 8272).

This Gasteromycete reminds one of an early stage of *Boletus* in peridial color, change of tissues to blue when cut or bruised, and in shape of spores. The gleba, however, does not separate from the columella (stipe) below and the hymenium lines chambers rather than tubes. In spore shape and presence of columella only is it similar to the brown or ochre-spored species of *Hysterangium*.

#### 7. *Melanogaster eurypermus* (Zeller & Dodge) comb. nov.

Syn. *Melanogaster ambiguus* var. *eurypermus* Zeller & Dodge, Ann. Mo. Bot. Gard. 22: 373. 1935.

Further study of fresh material of this fungus shows it to differ in so many points from *M. ambiguus* that the variety is raised to specific rank. The olivaceous color and spongy surface of *M. ambiguus* are in striking contrast to the warm, brown, smooth and firm surface of *M. eurypermus*. The two also differ in structure of peridium, and color, walls, and shape of spores (FIG. 40, 45). In additional material the size of spores in *M. eurypermus* is found to range up to  $18\mu$  long and  $11\mu$  broad.

### 8. *Melanogaster luteus* nom. nov.

Syn. *Melanogaster microsporus* Mattiolo, Beitr. Krypt.-Fl. Schweiz 8<sup>2</sup>: 37–29. 1935.—Not *Melanogaster microsporus* Velenovsky, Ceske Houby 809. 1922.

Fructifications subglobose to reniform, 2–3 cm. in diam., golden-yellow to mars-orange, drying buckthorn-brown or darker; peridium duplex, outer layer golden-yellow, 100–140  $\mu$  thick, of large loosely meshed hyphae with clamp connections, inner layer more compact, of parallel hyphae, underlaid by a parenchyma of the outer gleba; gleba brownish-black with yellowish-white septa; septa of hyaline gelatinized hyphae, 30–50  $\mu$  broad; basidia piriform, 5–8  $\times$  4–6  $\mu$ , hyaline, 4–8-spored (mostly 8); spores dark-brown, ellipsoid, minute, 3–4.3  $\times$  2–2.3  $\mu$  (FIG. 37); odor mildly of garlic.

Hypogeous, under maple, chestnut, and pine. Como Province, Italy, and Linn County, Oregon.

This species is preferred by pine squirrels, the spawn where the Oregon collection was taken having previously been raided by these rodents.

#### SPECIMENS EXAMINED:

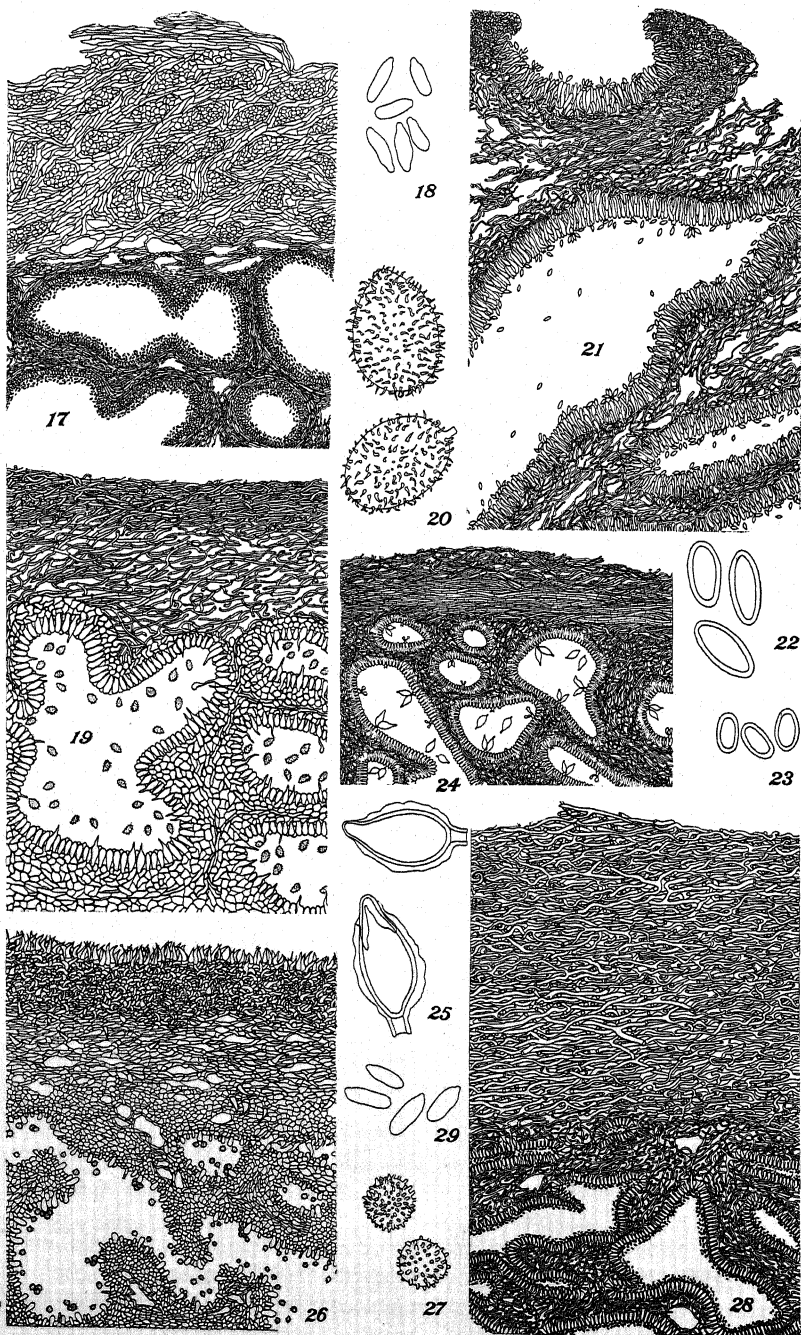
Italy: Como Province, Rodero, O. Mattiolo, type of *M. microsporus* Mattiolo (portion in Zeller Herb.).

Oregon: Linn County, Trout Creek Recreation Area, Sept. 23, 1937, S. M. Zeller, 8312.

### 9. *Melanogaster macrocarpus* sp. nov.

Fructificationes “snuff-brown” vel “tawny-olive,” siccatae obscuriores, 6–12 cm. crassae; peridio circa 100–140  $\mu$  crasso, prosenchymato, cellulis crasso-tunicatis, circa 7  $\mu$  diam., composito, peridium tramale gelatinosum interruptum investiente; gleba atrata; septis albis gelatinosis; basidiis hyalinis, crassoclavatis, 4-sporis, sterigmatibus circa 3  $\mu$  longis; sporis lato-obovoideis, 12–15  $\times$  8–11  $\mu$ , fuscis.

Fructifications large, up to 12  $\times$  8  $\times$  6 cm., snuff-brown or tawny-olive, drying russet to mars-brown and darker; peridium about 100–140  $\mu$  thick, of a compact prosenchyma which is dark-brown at the surface shading to lighter within, its cells thick-walled, about 7  $\mu$  in diam., overlying a gelatinous tramal peridium about 50–100  $\mu$  thick, which is interrupted by prosenchymatous plates (septa) which have unbroken connection with the peridium



FIGS. 17-29.

and extend into the gleba (FIG. 30); gleba black, mottled by white septa which are about  $30\text{--}60\ \mu$  thick, of gelatinous hyphae and a central plate of prosenchyma; basidia hyaline, broadly clavate, 4-spored, sterigmata  $\frac{1}{5}$  the length of the spores; spores broadly obovoid,  $12\text{--}15 \times 8\text{--}11\ \mu$ , dark-brown (FIG. 31); odor of spoiled silage or of onions without the tear-producing qualities.

In forest duff under conifers, especially *Tsuga*, August to October. Clackamas and Lane Counties, Oregon.

Oregon: Clackamas County; on trail to Paradise Park from Twin Bridges Forest Camp, *S. M. Zeller*, 7759, 8015, 8230, type, *Dr. and Mrs. D. P. Rogers* (*Zeller*, 8262); Lane County, Belknap Springs, *S. M. Zeller & G. R. Hoerner* (*Zeller*, 8241).

This species is doubtless near *M. microsporus* Vel., type of which is not available.

#### 10. MELANOASTER PARKSII Zeller & Dodge.

Since the preparation of the manuscript dealing with *Melanogaster* (*Ann. Mo. Bot. Gard.* 23: 639–655. 1936) the writer has had opportunity to study two collections taken from California by H. W. Harkness, and which because of their historical value should have been cited as *M. Parksii*. These were his numbers 68 and 128 referred, by him respectively, to *M. aureus* Tul. and *M. sarcomelas* Tul., reported as from Alameda, Marin, and Placer Counties, California. (*Cal. Acad. Sci. Proc.* III 1: 260–261. 1899.)

#### 11. DENDROGASTER CONNECTENS Bucholtz.

The type material of this species in the Farlow Herbarium at Harvard University has become a mixture of two species of *Dendrogaster*. The material is preserved in 3 vials labelled by F. Bucholtz and all bearing the same collection number (no. 284) but unfortunately each vial bears a different collection date. Doubtless no. 284 was the type collection taken Aug. 14, 1899, and since the two other vials bear two subsequent dates (Aug. 25, 26, 1907, and July 30, 1916) in his handwriting, evidently Bucholtz assumed the two subsequent collections to be *Dendrogaster connectens* and assigned them the same number (no. 284). The material of the second species in the mixture, therefore, was



probably introduced unwittingly through one or both of the subsequent collections.

There are in all approximately 10 very small fructifications which have been cut into two or more pieces. The writer has examined practically all of these, however, and segregated them into separate vials. There are about 4 fructifications of *D. connectens* all of which are quite young although they contain a few spores which are apparently mature. Fortunately there is such extreme difference between the spores of the two species that they were readily segregated. In all of the material there are so many unattached spores that *attached spores* only furnished the one definite criterion for segregating the two types.

The size of the spores of *D. connectens* is slightly variable,  $14-21 \times 10.6-12.4 \mu$  without the utricle, up to 14 or  $15 \mu$  broad including the utricle. The peridium is  $70-100 \mu$  thick.

For the other species, type material of which was mixed with that of *D. connectens*, the writer is proposing the name:

## 12. *Dendrogaster olivaceus* sp. nov.

Fructificationes subglobosae, deorsum costatae, usque ad 1.5 cm. crassae, superficie hebeti, laevi, siccitate maculosae pallido et fusco-brunneae; peridio  $75-200 \mu$  crasso, hyalino, prosenchymatico superficie fuscato, hyphis compacte implicatis composito; columella simplici vel ramosa, saepe percurrenti, prosenchymatica; gleba fulva, locellis mannii; septis tenuibus; basidiis clavatis, 1-4-sporis, sterigmatibus brevibus; sporis immaturis laevibus, utriculo pellucido laxo rugoso textis, obovoideo-lanceolatis, apiculo pedicelloque prominentibus,  $19.5-35.5 \times 10.6-14.2 \mu$  (e basidiis unisporis,  $38-45 \times 15-18 \mu$ ), luteobrunneis; sporis maturis fuscatis apiculo obtuso utriculoque rugoso.

Fructifications subglobose, costate below, up to 1.5 cm. in diameter; surface dull, even, white and overlaid by a white, thin weft of entangled mycelium, drying mottled light and dark-brown; peridium  $75-200 \mu$  thick, hyaline, prosenchymatous, surface darker, of closely woven hyphae (FIG. 24); columella simple or branched, sometimes percurrent, prosenchymatous; gleba of rather large cavities, separated by thin septa, light-grayish becoming tawny in old specimens; basidia clavate, 1-4-spored with very short sterigmata; spores smooth when young covered with a clear more or less closely applied utricle, obovoid-lanceolate with a cylindrical or capitate apiculus and prominent claw-like base,  $19.5-35.5 \times 10.6-14.2 \mu$  (spores from 1-spored basidia larger,  $38-45 \times 15-18 \mu$ ), light yellowish-brown, mature spores smaller,

darker brown with rounded or broadly apiculate tips, and with a closely applied but wrinkled utricle which may rupture where the rounded tip protrudes (FIG. 25).

On the ground under leaves. Benton County, Oregon, Santa Cruz County, California, and Mikhailovskoe, near Moscow, U. S. S. R. (Russia).

As mentioned above, the type of this species was found mixed with the type of *D. connectens* in the Farlow Herbarium. It perhaps was collected on August 25, 26, 1907, or July 30, 1916. The spores are very similar to those of *Hymenogaster olivaceus*. (Ann. Mo. Bot. Gard. 21: 689. 1934.)

A collection by H. E. Parks (no. 503), taken in California, is identical with the type of *D. olivaceus*. This collection was previously referred to *Hymenogaster olivaceus* and other collections so referred may be thus incorrectly identified. Fresh material should always be sectioned vertically to observe at once any sterile tissues such as columella.

#### SPECIMENS EXAMINED:

U. S. S. R. (Russia): Moskva, Mikhailovskoe, *F. Bucholtz*, no. 284 in part, type.

California: Santa Cruz County, Felton Big Trees, *H. E. Parks*, 503, Apr. 13, 1919 (in Zeller and Univ. of Calif. Herb.).

Oregon: Benton County, near Corvallis, *S. M. Zeller*, 4606, April 21, 1937.

### 13. *Hydnangium ellipsosporum* sp. nov.

Fructificationes subglobosae, circa 1-2 cm. altae, 1-1.3 cm. crassae, albae vel pallido-ochraceo-luteae, laeves; peridio 80-180  $\mu$  crasso, strato externo compacto facile separabilo, interno laxo, hyphis hyalinis vel pallido-luteis intertexto; gleba cremicolorata, ochraceo-lutescenti; locellis irregularibus, medio-magnitudinis; septis circa 80-90  $\mu$  crassis (hymeniis annumeratis), parenchymatibus; basidiis 1-2-sporis, clavatis, 25-31  $\times$  11-17  $\mu$ , sterigmatibus 7-9  $\mu$  longi; sporis lato-ellipsoideis, ochraceis, echinulatis, 16.5-21 (23)  $\times$  12-15 (16)  $\mu$ .

Fructifications subglobose, usually taller than broad, about 1-2 cm. tall, 1-1.3 cm. broad, white to pale ochraceous-buff, smooth; peridium 80-180  $\mu$  thick, the outer part of very compact intertwining hyphae (FIG. 19), the inner part of very open meshed hyphae, allowing the outer peridium to be easily separable; gleba cream-color, becoming ochraceous-buff; cavities medium size;

septa about 80–90  $\mu$  thick including the 2 hymenia with parenchyma between, often scissile at the angles where an open meshwork of hyphae occurs; basidia 1–2-spored (mostly 1), clavate 25–31  $\times$  11–17  $\mu$ ; sterigmata 7–9  $\mu$  long; spores broadly-ellipsoid, ochraceous, echinulate, 16.5–21(23)  $\times$  12–15(16)  $\mu$  (FIG. 20).

Under conifers, Benton and Clackamas Counties, Oregon. June to August.

This species is very distinct because of the very large ellipsoid spores (FIG. 20). Rather large white rhizomorphic strands adhere to the surface of the peridium of some specimens but this character was not general enough to incorporate in the diagnostic description.

#### SPECIMENS EXAMINED:

Oregon: Benton County, Alsea Mountain, June, 1937, *Dr.* and *Mrs. D. P. Rogers*, 463, type (in *Rogers Herb.* and *Zeller Herb.*, 8457); Clackamas County, Twin Bridges Forest Camp, Aug. 9, 1937, *D. P. Rogers* (in *Zeller Herb.*, 8254).

#### 14. *HYDNANGIUM LAEVE* (Hesse) Zeller & Dodge.

In our publication on *Arcangeliella*<sup>2</sup> the collection by R. Thaxter (*B2H*) taken at Cranberry, N. C., was incorrectly referred to *A. asterosperma*. There is one whole fructification in the collection. It has no sterile base nor lactiferous ducts in the sterile tissues. Thaxter's collection *B2, H*<sup>1</sup>, from Burbank, Tennessee, similarly referred, also lacks the characteristics of *Arcangeliella*. Even in tiny specimens, 2 mm. in diameter, which usually show sterile tissues at their base, there are no sterile base nor lactiferous ducts. Both of these collections are *Hydnangium laeve*.

#### 15. *Hydnangium setigerum* sp. nov.

Fructificationes 0.5–1.5 cm. crassae; subglobosae, rhizomorphi tenuibus affixis; superficie villosula alba vel brunneola; peridio 170–200  $\mu$  crasso, strato externo hyphis hyalinis intertexto, superficie setigerosa, strato interno prosenchymato hyalino, lacunosibus; gleba cremeo-alba brunneolescenti; locellis irregularis; septis circa 50–60  $\mu$  crassis parenchymati hyalini; cystidiis laevibus tenuatis, moniliformibus; basidiis magnis, lato-clavatis, 1-, 2-, vel 4-sporis, sterigmatibus 5–6  $\mu$  long.; sporis sphaericis, brunneolis, echinulatis, 6–7  $\mu$  diam.

<sup>2</sup> Ann. Mo. Bot. Gard. 33: 631–634. 1936.

Fructifications 0.5–1.5 cm. in diameter, subglobose, attached by a single slender rhizomorph; surface delicately plush-like under a hand lens, white to light-brown; no sterile base nor columella; peridium 170–200  $\mu$  thick, of a meshy network of hyaline prosenchyma below a layer of interwoven hyphae with a superficial palisade of light-brown, thick-walled, sharp or capitate, lanceolate setae, 18–34  $\mu$  long, in places such setae also arising from various depths in the peridium and sometimes extending from the inside of the peridium into the outer glebal chambers (FIG. 26); gleba creamy-white, changing light-brown; cavities small, irregular; septa 50–60  $\mu$  broad, of hyaline parenchyma; cystidia tapered, smooth or moniliform; basidia large, broadly clavate, 1-, 2-, or 4-spored; sterigmata 5–6  $\mu$  long; spores spherical, light brown, with short, blunt, echinulae, 6–7  $\mu$  in diam. (FIG. 27), (giant spores from 1-spored basidia 9–10  $\mu$  and with more prominent echinulae).

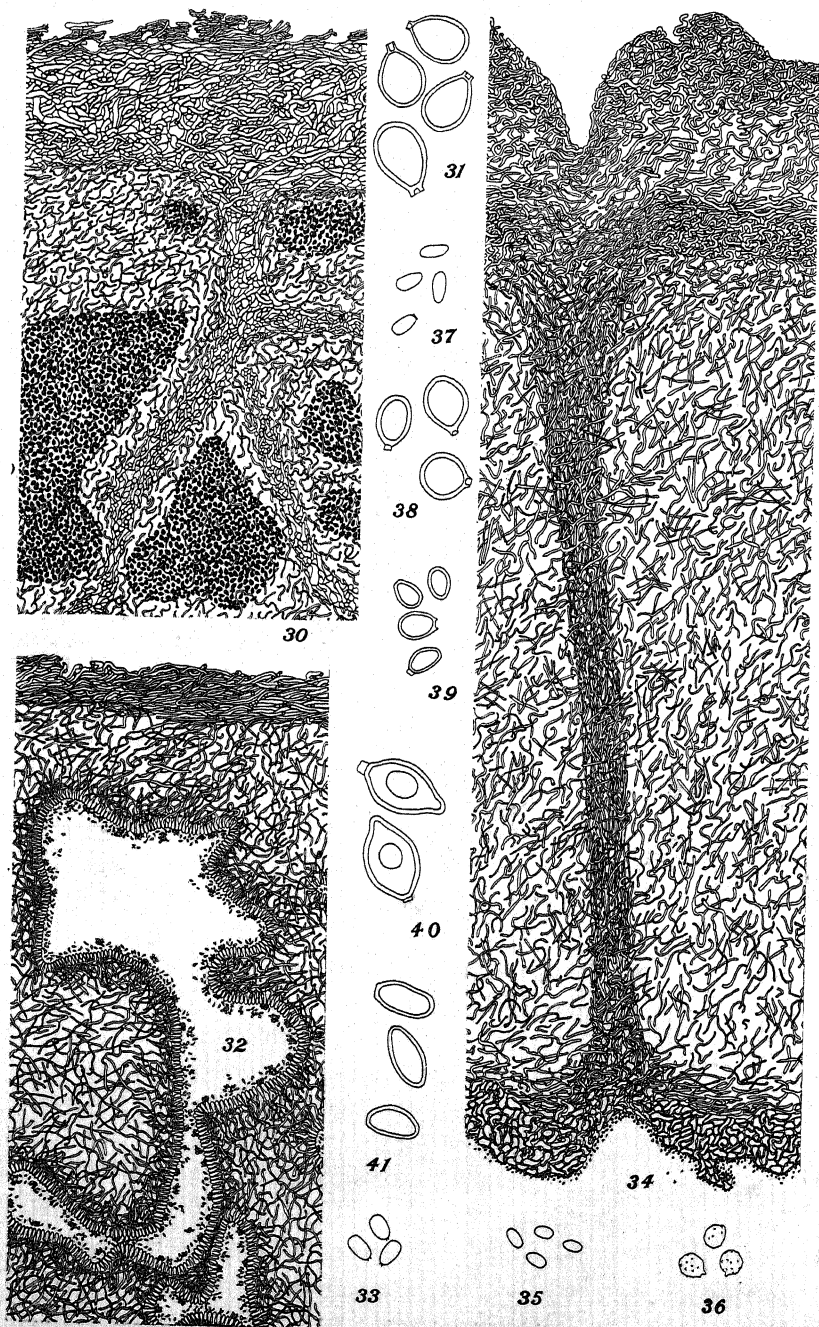
Under moss in dense coniferous woods, Roaring River Fish Hatchery, Linn County, Oregon, Mar. 20, 1934, S. M. Zeller, 8202, type; Benton County, Oregon, Alsea Mt., Dr. and Mrs. D. P. Rogers, Oct. 3, 1937.

*Hydnangium setigerum* is a most distinctive species. The setae of the peridium occurring at various levels and in places arising from and extending inward from the inside of the peridium are difficult to explain (FIG. 26). They do not stain particularly dark in KOH as in many of the species of *Hymenochaete*. Again, the moniliform cystidia, similar to those of certain species of *Aleurodiscus*, are prominent and characteristic. *Arcangeliella pilosa* has erect hairs on the surface of the peridium but they are not thick-walled as the setae in *H. setigerum*.

#### 16. ELASMOMYCES RUSSULOIDES Setchell.

In a recent publication on the genus *Arcangeliella*<sup>3</sup> this species was referred to synonymy with *A. alveolata* (Cooke & Masee) Zeller & Dodge. Since then Dr. Setchell has kindly sent a portion of the type of *E. russuloides*. It was collected by Dr. Setchell, April 29, 1905, and is a good species of *Elasmomyces*. The material I had previously studied and which was erroneously labeled as *type* was collected by Dr. N. L. Gardner, Nov. 24, 1904. The latter is *A. alveolata*, has lactiferous ducts and columella, but lacks

<sup>3</sup> Zeller, S. M. & Dodge, C. W. *Elasmomyces*, *Arcangeliella*, and *Macomranites*. Ann. Mo. Bot. Gard. 23: 620. 1936.



FIGS. 30-41.

the definite stipe and the reddish peridium which is so evident in dried material of *E. russuloides*. There is a similarity in the markings of the spores of *Arcangeliella alveolata*, *A. Gardneri*, and *Elasmomyces russuloides*, but those of *A. Gardneri* are somewhat ellipsoid while the spores of the other two species are spherical.

#### 17. *GASTROSPORIUM SIMPLEX* Mattirollo.

The writer has had opportunity to study type material of this species from the Farlow Herbarium, Harvard University. It would appear that Mattirollo<sup>4</sup> and Pilat<sup>5</sup> have both overlooked the roughness of the spores (FIG. 36). Under oil immersion and also with dark field illumination the verrucosity shows plainly. The genus description therefore should be emended to include verrucose spores.

Because of the type of development one may agree with Pilat that *Gastrosporium* be placed in a family by itself. Since the work of Pilat indicates the development of the fructifications of *Gastrosporium* to be the converse of that described by Fitzpatrick<sup>6</sup> for *Phallogaster*, the writer would place the family, *Gastrosporiaceae* Pilat, in another series of development parallel with that of the *Hysterangiaceae*, but doubtless outside the *Hysterangiales*.

#### 18. *Hysterangium Darkeri* sp. nov.

Fructificationes 1-4 cm. crass., depresso-globosae, lobulatae, "deep grayish olive" pellucidae, inquinatae, "pale olive buff" vel "avellaneous" siccatae; superficie glabra; superne funiculi fere desunt, inferne inconspicui; columella percurrans ramosaque, lamellis radiantibus ex fructificationis axe ortis, hyphis gelatinosis hyalinis compositis; peridio tenui evanescenti, 35-100  $\mu$  crass., hyphis tenuibus composito, super peridium tramiatem formato; gleba gelatinosa, "dark-ivy-green," "slate-olive" siccata, in strato crasso externo novissimis glebae partibus cum insulis parenchymaticis evolventibus; septis 80-125  $\mu$  crass., hyphis laxis, septatis, parallelibus, gelatinosis composita; basidiis irregulariter cylindraceutis 4-vel 8-sporis, 17-22  $\times$  3-7  $\mu$ ; sporis lato-ellipsoideis, sessilibus, "olive-green," singulatim hyalinis, 4-5  $\times$  2-2.5  $\mu$ .

<sup>4</sup> Mattirollo, O. *Memorie della Reale Accademie delle Scienze di Torino* (Ser. II) 53: 361. 1903.

<sup>5</sup> Pilat, A. *Bull. Soc. Myc. Fr.* 50: 37-49. *illus.* 1934.

<sup>6</sup> Fitzpatrick, H. M. A comparative study of the development of the fruit body in *Phallogaster*, *Hysterangium*, and *Gautieria*. *Ann. Myc.* 11: 119-149. *illus.* 1913.

Fructifications 1-4 cm. in diameter, depressed globose, somewhat lobed, a translucent deep-grayish-olive, drying a dirty-pale-olive-buff to avellaneous, surface glabrous, a few fibrils below, almost wanting above; columella percurrent and with whitish cartilaginous lamellae radiating from the middle of the fructification; peridium thin, evanescent, 35-100  $\mu$  thick, of slender thin-walled hyaline hyphae, underlaid by a thick tramal peridium (FIG. 32); gleba gelatinous, dark-ivy-green drying slate-olive the newest parts of the gleba together with parenchymatous islands evolving in a thick external layer (tramal peridium?); septa 80-125  $\mu$  broad, of gelatinous loose septate hyphae about 3-4  $\mu$  in diam. bordered on each side by finer sub-hymenial hyphae which are closely entwined; basidia irregularly cylindrical, 4-8-spored (mostly 6), 17-22  $\times$  3-7  $\mu$ ; spores sessile, broadly ellipsoid, hyaline under the scope, olive-green *en masse*, 4-5  $\times$  2-2.5  $\mu$  (FIG. 33).

On ground in coniferous woods. Utah and California. Summer.

*H. Darkeri* is similar to *H. Phillipsii* in spore size and development of the gleba just beneath the peridium. It differs, however, in color, thickness, and structure of the peridium, size of basidia, number of spores per basidium and the fact that the spores are sessile. In *H. Phillipsii* the peridium is composed of a thin-walled pseudoparenchyma. It may be significant that the basidia in *H. Darkeri* are typical of those found in phalloids. The size of the spores is also of the same magnitude as those found in *H. Phillipsii*, *Phallobata*, *Phallogaster*, etc.

SPECIMENS EXAMINED:

Utah: Salt Lake County, East of Brighton (Silver Lake), elev. 9600 feet, *G. D. Darker*, 5957, type, Aug. 3, 1936 (in Farlow Herb., Harvard, and a portion in Zeller Herb.).

California: Siskiyou County, Mt. Shasta, 8000 feet, *W. B. Cooke*, 8580, July 14, 1937.

19. *Hysterangium affine* M. & R. *oreades* var. nov.

This variety is distinguished from the species by the softer texture of the gleba and its association with a conifer, under or near which it forms "fairly rings."

The basidia are 4-6-spored; spores 10-14.5  $\times$  4-5.3  $\mu$ , fusoid-

ellipsoid; gleba drying deep-grayish-olive to dark-ivy-green (soaked up slate-olive to deep-slate-olive).

Under or near *Abies lasiocarpa*, forming "fairy rings" 10 to 35 feet in diameter. Utah. Elevation 8750-9000 feet.

Some of the fructifications project slightly above the surface of the ground. Dr. Darker's collection notes include the statement that "their presence was otherwise indicated by little pit-like areas where mature fruiting bodies had decayed or by the raised bump where the mature fruiting bodies had pushed up the earth. . . . The best development of fruiting bodies was in gravelly soil. The specimens were attached to one another in clumps or were separate, the larger groups bulging the surface of the soil and thus evident before breaking through."

#### SPECIMENS EXAMINED:

Utah: Salt Lake County, Brighton (Silver Lake), *G. D. Darker*, 5873, type, July 30, and 5945, Aug. 3, 1936.

#### 20. HYSTERANGIUM PHILLIPSII Harkness.

It was necessary to restudy the material of *H. Phillipsii* to make sure its distinction from *H. Darkeri*. Specimens sent from Ohio by W. R. Lowater were given especial consideration. When soaked in water these nearly regained their original stature, and proved to be *Phallogaster saccatus* Morgan, which has spores the same magnitude as those of *H. Phillipsii* but other structures distinct. Thus, it appears that so far as known *H. Phillipsii* is a Pacific Coast species.

#### 21. HYSTERANGIUM STOLONIFERUM var. AMERICANUM Fitzpatrick.

Since the publication of *Hysterangium*,<sup>7</sup> where *H. stoloniferum* var. *americanum* Fitzpatrick was considered as synonymous with *H. clathroides* Vitt., the writer has had opportunity to examine fresh material from Oregon and California which undoubtedly is the same as that described by Fitzpatrick. Two collections (nos. 269 and 299) from Prof. James McMurphy taken by him near Stanford University answer this description and seem to be

<sup>7</sup> Ann. Mo. Bot. Gard. 16: 83-128. *illus.* 1929.



identical with that described by Fisher<sup>8</sup> from California. Fruiting bodies taken by myself from Comstock, Oregon, January 12, 1938, were produced on large cord-like stolons up to 15 cm. long which in turn were branches from similar large white rhizomorphs which extended for several feet under the forest duff. The general habit of this fungus in the forest duff is entirely distinct from *H. clathroides* and *H. clathroides* var. *crassum*, as described by us, both of which I have collected in quantity. Fischer seems entirely justified in retaining Fitzpatrick's variety name.

## 22. PHALLOBATA ALBIDA Cunningham.

This odd genus and species was collected in Linn County, Oregon, in March. It was growing on decayed wood (humus) under maple, hazel, and Douglas fir. It has characters reminding one of *Hysterangium Phillipsii* on the one hand and *Phallogaster sacatus* on the other. The queer lobes surmounting the gleba proper are reminiscent of *Phallogaster* or *Hysterangium* gone wrong, or perhaps more properly a degenerate from the Phallales. It is the writer's opinion that this genus, together with *Phallogaster*, should be referred to the Hysterangiaceae, as Fischer has done.

## GELOPELLACEAE fam. nov.

Fructificationes subglobosae; peridio tenui, stratum crassum continuum gelatinosum investiente; gleba colorata, locellis columellaque praedita, locellis hymeniis circumdatis; sporis levibus, parvis, coloratis.

Fructifications subglobose; peridium thin, surrounding a thick, continuous, gelatinous layer; gleba colored, with locules and a columella; walls of locules lined with a basidial hymenium; spores smooth, small, colored.

The type genus is *Gelopellis*.

## *Gelopellis* gen. nov.

Fructificationes hypogaeae, subglobosae; perido tenui, stratum, crassum, gelatinosum, continuum investiente; columella simplici vel dendroidea, gelatinosa; gleba fusca vel obscure olivacea locellis parvis praedita; hymenio laevi, e basidiis paraphysisque composito; sporis parvis, ellipsoideis, levibus, brunneis.

<sup>8</sup> Fischer, Ed. Hypogaeen-Studien. I. Zur Kenntnis der Gattung *Hysterangium*. Ber. Schweiz. Bot. Ges. 48: 29-44. illus. 1938.

Fructifications hypogeous, subglobose; peridium thin, surrounding a thick hyaline, gelatinous, continuous layer (FIG. 8) which entirely envelopes the fertile portion of the gleba, which is very dark-brown or deep-olivaceous; columella simple or branched, gelatinous; hymenium of basidia and paraphyses covering the walls of small cavities; spores small, ellipsoid, smooth, brown.

The type species is *Gelopellis macrospora*.

This South American genus is a representative of a line of development between the Hysterangiaceae and the Phallaceae. The thick gelatinous layer immediately under the peridium is not interrupted by sterile or fertile cavities such as those in the tramal peridium of *Hysterangium* nor by sterile plates (sutures) of cortical or fundamental tissue as found in the genera representing the Protophallaceae and the egg stages of those representing the Clathraceae. This uninterrupted gelatinous layer (tramal peridium) is similar to the gelatinous sheaths of egg stages in genera of the Phallaceae. This type of development, it would seem, marks another line from forms near the Hysterangiaceae but with undiscovered intervening links. For the present we are placing it in a new family, Gelopellaceae, by itself. This family is in the Hysterangiales just below the Phallaceae of the Phallales.

### 23. *Gelopellis macrospora* sp. nov.

Fructificationes 7-17 mm. crassae, subglobosae appendici radiciformi adfixae; peridio 180-320  $\mu$  crasso, lento, prosenchymato, super stratum hyalinum, gelatinosum, 2-4 mm. crassum; columella sparse dendroidea, basi conico gelatinoso glebam fere percurrente; gleba atrobrunnea; locellis sphaericis vel elongatis, circa 35-50  $\mu$  crassis; septis circa 35-45  $\mu$  crassis (hymenio annumerato), hyphis hyalinis 3-4  $\mu$  crassis parallelis vel reticulato-intertextis compositis; paraphysibus valde gelatinosis; basidiis 4-sporis, cylindraceis, 3-4  $\times$  12-18  $\mu$ ; sporis ellipsoideis, 7-14  $\times$  3.5-5  $\mu$ , obscure brunneis, levibus.

Fructifications 7-17 mm. in diam., subglobose, attached by a basal rhizomorphic cord; peridium 180-320  $\mu$  thick, of a tough meshy prosenchyma, covering a hyaline gelatinous layer 2-4 mm. thick, composed of fine somewhat vesiculose hyphae embedded in a translucent, colorless gel (FIG. 52); columella simple or somewhat branched, with a conic gelatinous base, extending as a narrow line to the summit of the gleba, of the same texture as the peridium (FIG. 8); gleba blackish-brown; cavities spherical to elongate, about 35-50  $\mu$  broad; septa about 35-45  $\mu$  broad (including hy-

menia), of parallel to reticulately meshed hyaline hyphae, 3–4  $\mu$  in diam.; hymenium of highly gelatinized paraphyses and slender basidia; basidia 4-spored, cylindrical, 3–4  $\times$  12–18  $\mu$ ; spores ellipsoid, 7–14  $\times$  3.5–5  $\mu$ , dark-brown, smooth (FIG. 53).

The very fine hyphae of the subperidial gelatinous layer (tramal peridium) are somewhat vesiculose but do not show the peculiarly nodose clamp-connections found in those of *G. Thaxteri*. The spores of *G. macrospora* have 10–15 times the volume of those of *G. Thaxteri* (FIG. 54).

SPECIMENS EXAMINED:

Chile: Concepcion, *R. Thaxter*, Hypog. No. 1, type (in Thaxter Bequest to Farlow Herbarium).

24. **Gelopellis Thaxteri** (Zeller & Dodge) Zeller comb. nov.

Syn. *Hysterangium Thaxteri* Zeller & Dodge, Ann. Mo. Bot. Gard. 16: 114–115. 1929.

KEY TO THE SPECIES OF GELOPELLIS

1. Peridium of interwoven hyphae; spores 3–4  $\mu$  long.....*G. Thaxteri*.
2. Peridium a meshy prosenchyma; spores 7–14  $\mu$  long.....*G. macrospora*.

**PROTOPHALLACEAE** fam. nov.

Fructificationes subglobosae, hypogaeae vel epigenae; peridio plerumque tenui, e textu primario composito, peridium tramaleum crassum gelatinosum laminis radiantibus interruptum investiente; gleba gelatinosa vel cartilaginosa, olivacea vel brunneola, a lamellis gelatinosis e basi vel columella radiantibus dissiecta, cellulis ab initio cavis et tandem subfarctis, septis basidiophoris; sporis parvis, ellipsoideis, olivaceis vel brunneolis.

Fructifications subglobose, hypogeous or epigeous; peridium usually thin, of primary tissue, covering a thick gelatinous tramal peridium (volva) which is interrupted by radial membranes of primary tissue having unbroken connection with the peridium and gleba; gleba gelatinous or cartilaginous olivaceous or brownish, usually sectored by gelatinous plates radiating from the base or from a columella; cavities at first empty then almost filled with spores; basidial hymenium lining cavities; spores small ellipsoid, olivaceous or brownish.

25. **PROTUBERA AFRICANA** Lloyd.

Fructifications about 1.5–2 cm. in diameter, subglobose from a small rhizomorphic base, the surface smooth between reticula-

tions, brown; peridium a thin, tough layer (rind), composed of pseudoparenchyma about  $14-20\mu$  thick, covering a white layer (tramal peridium) of loosely spaced thin hyphae imbedded in a gel, 2-3 mm. thick; columella branched from the base but the branches not visibly purcurrent, gelatinous; gleba olivaceous-brown, gelatinous (of the consistency and appearance of that of the greenish-spored species of *Hysterangium*) with a whitish enveloping membrane of fundamental tissue which has unbroken connection with the rind by occasional membranes (cortical plates) which extend through the intervening gelatinous tramal peridium, cavities small, almost filled with spores; septa of hyaline gelatinous hyphae; basidia phalloid, mostly 6-8-spored (4-8-); spores ellipsoid-ovoid, pip-shaped, or oblong, distinctly showing the sterigmatic scar, almost sessile,  $5.5-6.3(8.5) \times 2.5-3(3.5)\mu$ .

In damp clay soil, Union of South Africa.

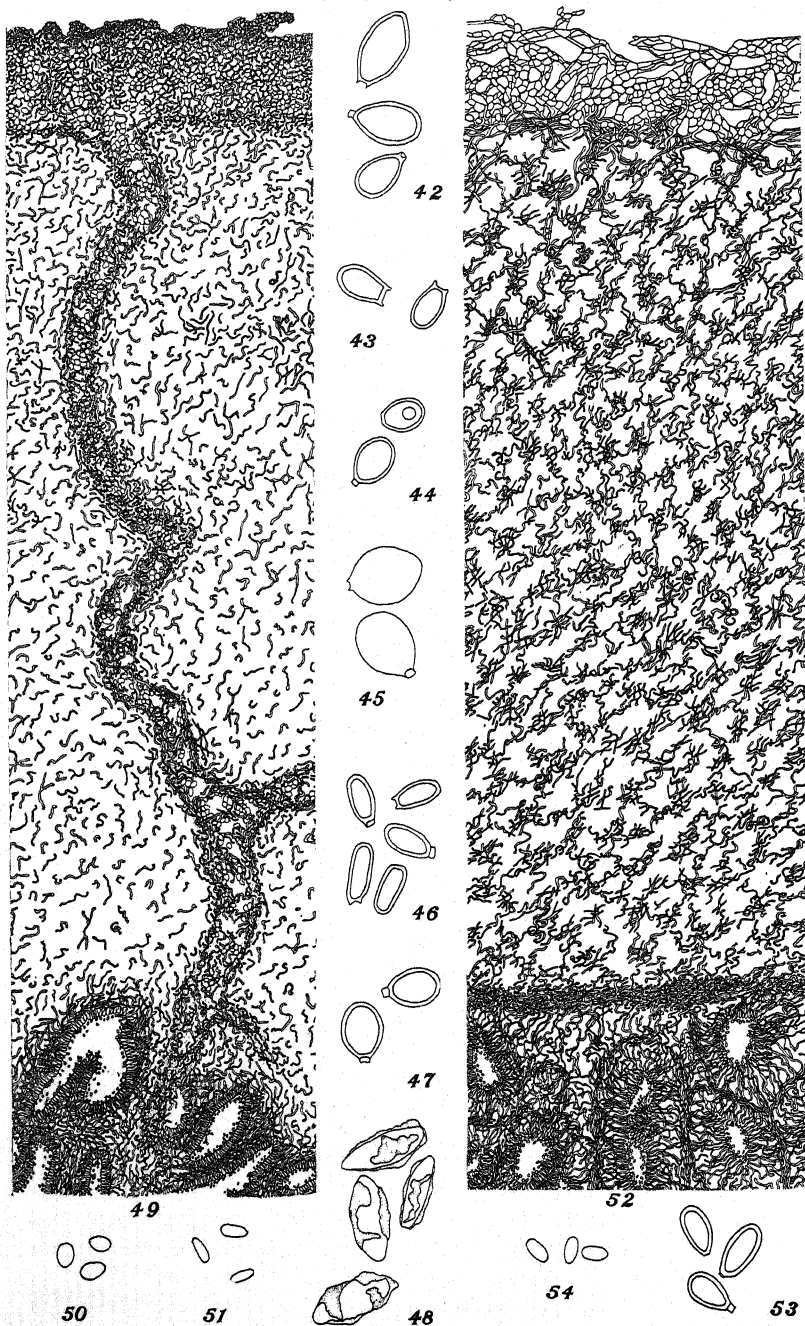
Lloyd (Myc. Notes 64: 987. 1920) described 3 layers in the peridium. The inner one, however, is distinctly a part of the fertile glebal tissue or the arrested pseudoparenchymatous fundament of a receptaculum. Lloyd described no columella and in addition states that "The African species differs in not having the tramal plates. . . ." It is true that the sterile branches from the base are not as prominent as in *Protuberia Maracuja*. There are, however, very definite sterile plates and it seems to the writer that *P. africana* is well within the scope of the genus as described by Möller. This genus belongs in that developmental series which we are including in the Protophallaceae.

### CALVARULA gen. nov.

Fructificationes subsphaericae; peridio tenui, strato externo e hyphis dense intertextis, peridium tramalem crassum gelatinosum, laminis radiantibus interruptum investienti; gleba primo carnosa, dein brunneola sporarum sine capillitia pulvere repleta, postremo excavata; sporis levibus, brunneis.

Fructifications subspherical, peridium an outer rind of fundamental tissue overlying a thick layer (tramal peridium) of loosely interwoven hyphae embedded in a gelatinous matrix, through which very thin plates of fundamental tissue radially and unbrokenly connect the peridium with an inner thin layer of fundamental tissue next to the gleba; gleba fleshy, becoming a brownish powdery, homogeneous spore-mass without capillitium; spores smooth, brown *en masse*.

TYPE SPECIES: *Calvarula excavata*.



FIGS. 42-54.

26. *Calvarula excavata* sp. nov.

Fructificationes subsphaericae, circa 1.5 cm. crassae, superficie coactiloidea vel fibrillosa, molli alba, colori brunneo foedata; peridio tenui, hyphis magnis intricatis composito, peridium tramalem 1.5–3 mm. crassum, gelatinosum laminis radiantibus interruptum investiente; gleba primo carnosae, dein brunneolae, sine capillitio, pulvere sporarum repleta, postremo excavata; sporis brunneolis, levibus, ellipsoideis vel ovoideis,  $3-3.5 \times 1.7-2.2 \mu$ .

Fructifications subspherical, up to 1.5 cm. in diameter; surface felty to fibrillose, flaking off, soft, chalky white, staining more or less brownish (where bruised?), changing brown in preservative; peridium thin, of loose, coarse hyphae having occasional clamp-connections, covering a tramal peridium 1.5–3 mm. thick of very fine, hyaline hyphae embedded in a gelatinous matrix through which thin plates of fundamental tissue (cortical plates) radially connect unbrokenly the peridium with an inner thin layer of fundamental tissue next to the gleba; gleba at maturity of brownish, powdery, homogeneous spore-mass without capillitium; spores subhyaline (brown *en masse*), smooth, ellipsoid to ovoid,  $3-3.5 \times 1.7-2.2 \mu$  (FIG. 35).

Among leaves on boggy farm hummock, Cocount Grove, Florida, R. Thaxter, Nov., 1897, type (in Farlow Herb., Harvard Univ.).

There are three very mature fructifications in the type collection of *C. excavata*. They are shrunken in the preservative but when transferred to water for a time regained their original size. Other than the field note given by Dr. Thaxter there is no information concerning the glebal structure and dehiscence. In preservative the gleba is about all dissolved from the chamber it once occupied (FIG. 10), leaving the peridial shell, so to speak; hence the specific name. It may be this description is founded on insufficient material. Nevertheless, the characters presented by the material indicate quite definitely the trends in the mode of development. Young stages, however, are desirable to reveal the exact nature of the gleba. No remains of important sterile tissue are apparent within the gleba.

As may be seen in figures 9 and 10 the "cortical plates" (Burt<sup>9</sup>), or plates of fundamental tissue which have unbroken

<sup>9</sup> Burt, E. A. Development of the receptaculum of *Clathrus columnatus* Bosc. Bot. Gaz. 22: 273–292. illus. 1896.

connection between the fundamental tissue of the rind (peridium) and a similar thin layer inside of the thick gelatinous layer are delineated as shallow furrows on the outer surface of the peridium and the inner surface of the tramal peridium (volva) like sutures joining the bones of a skull (FIG. 34); hence the generic name, *Calvarula*, a small skull.

The division of the gelatinous layer (volva) by these cortical plates (sutures) is indicative of the type of development of the fruit body. Sutures from the base extend in more or less straight plates up two-thirds or more of the distance to the summit, but divide the upper portion into sectors. This is similar to the condition in egg stages of genera of the Clathraceae, *Calvarula* being most similar to early stages of certain species in *Colonnaria* and *Clathrella*. Since no receptaculum is developed in *Calvarula*, the genus is referred to the Protophallaceae.

PROTOPHALLUS Murrill, Mycologia 2: 25. 1910.

Experience with a second species in this genus indicates that important morphological characters have been omitted from the description of the genus. This was undoubtedly due to the extreme maturity of the type collection, described at some length by Murrill. Through the kindness of Dr. W. C. Coker, the writer has obtained specimens preserved in liquid. These were collected by Dr. Coker at Cinchona, Jamaica, in 1900, nine years previous to the type collection. Examination of the type of *Protophallus jamaicensis* proved it to be congeneric with a distinctly different species collected by the late Dr. R. Thaxter at Buenos Aires, Argentina, in 1906.

Both species, however, have relatively thin, membranous peridia overlying thick gelatinous layers of fine loose hyphae embedded in a gel. This heavy gelatinous layer may be referred to as the tramal peridium and the thinner membranous outer layer as the fundamental or primary peridium, or as "peridium" for short.

The tramal peridium in these two species is not continuous. It is interrupted by radial plates or sutures composed of the same type of fundamental tissues as are found in the two peridia. These sutures have unbroken connections with the peridia and the gleba as is true in the button stages of genera within the family Cla-

thraceae of the Phallales. Murrill did not describe these sutures through the tramal peridium, but he described them at extreme maturity as "hyaline membranes," *i.e.*, "gleba . . . attached to hyaline membranes projecting from the inner surface of the peridium at regular intervals and floating free at maturity in a hyaline, gelatinous liquid." He states further, "The membranous plates to which the spore-masses were attached were as regular in arrangement as the partitions of an orange, but they did not extend to the center."

In both species of *Protophallus* there is a columella which reaches to the center of the fructification.

The description of the genus is therefore emended as follows to include the above morphological characters:

Fructifications epigeous, sessile, usually from a long cord-like rhizomorph, globose; peridium thin, membranous, overlying a thick gelatinous tramal peridium interrupted by radial membranous plates which have unbroken connection with the peridium and gleba; columella cylindrical, extending from the basal rhizomorph to the center of the fructification; gleba hysterangoid, sectoried by percurrent plates or membranes from the columella, gelatinous; hymenium lining walls of cavities; basidiospores minute, ellipsoid, colored.

Type species is *Protophallus jamaicensis* Murrill, *Mycologia* 2: 25. 1910.

The emended description of the type species is as follows:

#### 27. *PROTOPHALLUS JAMAICENSIS* Murrill.

Fructifications spherical, up to 4 cm. in diameter, surface viscid, smooth, avellaneous, becoming white at maturity; peridium 200–280  $\mu$  thick, of rather densely interwoven hyaline hyphae in a gelatinous matrix, covering a gelatinous tramal peridium, about 1–1.5 mm. thick, composed of fine hyaline hyphae very loosely dispersed through a gelatinous matrix, and interrupted by radial membranous plates (sutures) of the same structure as the primary peridium and having unbroken connection with the latter and the gleba; columella cylindrical, extending from the basal rhizomorph to the center of the fructification, gelatinous with a cartilaginous core; gleba hysterangoid, olivaceous, sectoried by percurrent, radial, gelatinous membranes or plates from the columella the sectors attached to the tramal peridium by the sutures;



cavities small, localized in the sectors, almost filled with spores; basidia not seen; spores oblong-ellipsoid, smooth, olivaceous,  $3.0\text{--}4.3 \times 1.2\text{--}1.8 \mu$  (FIG. 51).

The second species in the genus is:

28. *Protophallus brunneus* sp. nov.

Fructificationes sphaericae, 1.5–3.5 cm. crassae, appendici radiciformi adfixae, superficie alba vel sordida, levi sed leniter coactioidea, leniter reticulata; peridio tenaci, circa 175–250  $\mu$  crasso, hyphis hyalinis, intertextis, composito, peridium tramalem gelatinosum, circa 2–4 mm. crassum, laminis radiantibus interruptum investiente; columella alba, stratis externis cartilaginosis, intus gelatinosa, ad centrum fructificationis extendente, lamellis gelatinosis radiantibus ex fructificationis axe ortis; gleba hysterangioidea, pallido-olivaceo-brunnea vel caryophyllo-brunnea; locellis parvis; septis tenuibus, hyphis gelatinosis intertextis compositis; basidiis elongato-clavatis, 4–6-sporis; sporis lato-ellipsoideis, cumulo brunneis subhyalinis *sub lente*,  $5\text{--}6 \times 2.5\text{--}3 \mu$ .

Fructifications spherical, 1.5–3.5 cm. in diam., attached below by a single cord-like rhizomorph, surface white becoming sordid, smooth but somewhat felt-like, reticulated by a few lines (FIG. 3, 4); peridium thin, tough, about 175–250  $\mu$  thick, composed of interlacing and anastomosing hyaline hyphae, surrounding a gelatinous tramal peridium which is about 2–4 mm. thick (usually thickest below) and composed of an open-meshed anastomosing network of fine hyaline hyphae embedded in a gel, and through which radial cortical plates (sutures) have unbroken connection with the peridium and gleba; columella white, cord-like, with a tough cartilaginous sheath and gelatinous core, extending from the basal rhizomorph to about the center of the gleba, and from the summit of which radiate slate-colored, gelatinous plates to the tramal peridium (FIG. 49); gleba hysterangioid, light-olive-brown to clove-brown; cavities rather small; septa thin, of interwoven, gelatinized hyphae; basidia elongate-clavate; 4–6-spored; spores broadly ellipsoid, brown *en masse*, subhyaline under microscope,  $5\text{--}6 \times 2.5\text{--}3 \mu$  (FIG. 50).

In a park, Buenos Aires, Argentina, February and March, 1906, R. Thaxter, type (in Farlow Herbarium, Harvard University).

*Protophallus brunneus* differs from *P. jamaicensis* Murr. in several ways. The surface of the latter has a soft, smooth, viscid feel while that of the former has a felty roughness to the touch and is marked off distinctly by a few reticulate lines which are the superficial expression of the cortical plates (sutures). The gleba

of *P. jamaicensis* is more gelatinous and is dusky drab to blackish-brown and that of *P. brunneus* is light-olive-brown to clove-brown. The spores of the former are narrowly ellipsoid or bacillar and  $3-4 \times 1.2-1.8 \mu$  (FIG. 51) while the spores of *P. brunneus* are broadly ellipsoid, rounded at both ends and  $5-6 \times 2.5-3 \mu$ .

## 29. RHOPALOGASTER TRANSVERSARIUS (Bosc) Johnston.

Material of this interesting genus came to hand after the manuscript and plates for this paper were otherwise finished. Illustrations of spores and relation of gleba to peridium are therefore not included for comparison. A rather casual examination of the microscopic characters gives no less assurance than Johnston<sup>10</sup> claimed for its inclusion among the *Hysterangiaceae*. It is definitely a brown-spored form with less gelatinous-cartilaginous tissues than in most of the other representatives of the *Hysterangiales* except that group of brown-spored species which have been referred tentatively to *Hysterangium*, namely *H. occidentale* Harkn., *H. neglectum* M. & R., *H. neocaledonicum* Pat., and perhaps *H. album*. *Rhopalogaster* is an aberrant genus perhaps branching from the main line of development near these brown-spored species of *Hysterangium*.

Tentative keys to the families and genera of the *Hysterangiales*, which the writer has had opportunity to study, are included herewith.

### KEY TO FAMILIES OF THE HYSTERANGIALES

- I. Tramal peridium continuous, thick, gelatinous.
  - 1. Gelopellaceae (one genus, *Gelopellis*).
- II. Tramal peridium not continuous.
  - A. Tramal peridium not well developed or if so, cartilaginous, thin, interrupted by fertile or infertile cavities usually not filled by peridial tissue.....2. *Hysterangiaceae*.
  - B. Tramal peridium thick, gelatinous, interrupted by thin plates of peridial tissue having unbroken connection with the fundamental peridium and sectors of the gleba.....3. *Protophallaceae*.

### KEY TO GENERA OF THE HYSTERANGIAEAE

- I. Columella simple, thick, percurrent.....1. *Rhopalogaster*.
- II. Columella cushion-like, or thin and much branched, but not percurrent.
  - A. Peridium with thick, warty or head-like, sterile outgrowths.
    - 2. *Phallobata*.

<sup>10</sup> Johnston, J. R. On *Cauloglossum transversarium* Fries (Bosc). Amer. Acad. Arts & Sci., Proc. 38: 59-74. illus. 1902.

- B. Peridium more or less uniformly thick.  
 a. Fructifications more or less globose, not stalked, hypogeous. 3. *Hysterangium*.  
 b. Fructifications pear-shaped, stalked, epigeous. . . . 4. *Phallo-gaster*.

KEY TO GENERA OF THE PROTOPHALLACEAE

- [illegible]

30. *Secotium diminutivum* sp. nov.

Fructificationes 8-9 mm. altae; pileo conico vel angusto-ovoideo, 4-5 mm. alto, 3-4 mm. lato, glabro, albo dein argillascente; stipite 3-4 mm. longo, 0.5-1.0 mm. crasso, albo dein sordido, glabro, sursum in columellam tenuem percurrentem procurrente; peridio 175-280  $\mu$  crasso, strato simplici hyalino prosenchymatico constituto; gleba alba dein sordida; locellis parvis, plerumque e columella radiantibus; septis tenuibus, hyphis tenuibus, hyalinis, compactis compositis; cystidiis nullis; basidiis, cylindraceis, prominentibus, tetrasporis; sporis subsessilibus, hyalinis, fusiformibus, infra subtruncatis, levibus sed in utriculo saepe diffracto inclusis, 12-16  $\times$  5-6  $\mu$ .

Fructification 8–9 mm. tall; pileus conical or narrowly ovoid, 4–5 mm. high, 3–4 mm. broad, smooth, white becoming clay-color (FIG. 12); stipe 3–4 mm. long, 0.5–1.0 mm. in diam., white becoming sordid, smooth, extended above into a slender, nearly percurrent columella (FIG. 13); peridium 175–280  $\mu$  thick, of a single hyaline, prosenchymatous layer; gleba white becoming sordid; cavities mostly radiating from the columella, small; septa thin, of very compact, parallel, slender, hyaline hyphae; cystidia none; basidia cylindrical, projecting above the hymenium, 4-spored (sometimes 2-spored); spores almost sessile, hyaline, fusiform, quite truncate below (as *Hysterangium* spores), smooth when young, but with a utricule which is often ruptured at maturity, 12–16  $\times$  5–6  $\mu$  (FIG. 48).

Under old oak leaves on the ground, north of Corvallis, Benton County, Oregon, *S. M. Zeller*, April 21, 1937, type.

### EXPLANATION OF FIGURES

The drawings in the following figures were prepared by Mrs. D. P. Rogers.

FIG. 1. Exterior of fructification of *Truncocolumella citrina*.  $\times 1$ .

FIG. 2. Median vertical section of fructification of *T. citrina*, showing the relation of stump-like columella and gleba.  $\times 1$ .

FIG. 3. Exterior of fructification of *Protophallus brunneus*. The depressions indicate the position of the cortical plates within.  $\times 2$ .

FIG. 4. Median vertical section of fructification of *P. brunneus*, showing relation of parts.  $\times 2$ .

FIG. 5. Exterior of mature fructification of *Truncocolumella rubra*.  $\times 1$ .

FIG. 6. Median vertical section of the fructification shown in figure 5. Notice the stump-like columella.  $\times 1$ .

FIG. 7. Exterior view of a fructification of *Gelopellis macrospora*.  $\times 2$ .

FIG. 8. Median vertical section of the fructification shown in figure 7. Notice the thick continuous gelatinous envelope (tramal peridium) surrounding the black gleba.  $\times 2$ .

FIG. 9. Exterior of a mature fructification of *Calvarula excavata*, showing the depressions which indicate the position of the sutures which divide the gelatinous tramal peridium within.  $\times 2$ .

FIG. 10. Median vertical section of the fructification shown in figure 9. The gleba is gone leaving the hollow volva or tramal peridium. Lines on the interior show the position of the sutures.  $\times 2$ .

FIG. 11. Exterior of a fructification of *Rhizopogon separabilis* showing the separation of the peridium.  $\times 1$ .

FIG. 12. Exterior of a fructification of *Secotium diminutivum*.  $\times 2$ .

FIG. 13. Median vertical section of the fruiting body shown in figure 12.  $\times 2$ .

FIG. 14. Radial section through the peridium and gleba of *Rhizopogon exiguus*, showing structure and relation of tissues.  $\times 42.5$ .

FIG. 15. Spores of *R. exiguus*.  $\times 825$ .

FIG. 16. Radial section through the peridium and gleba of a young fructification of *Truncocolumella citrina*.  $\times 42.5$ .

FIG. 17. Radial section through the peridium and gleba of *Rhizopogon separabilis*.  $\times 42.5$ .

FIG. 18. Spores of *R. separabilis*.  $\times 825$ .

FIG. 19. Radial section through peridial and glebal tissues of *Hydnangium ellipsosporum*.  $\times 42.5$ .

FIG. 20. Spores of *H. ellipsosporum*.  $\times 825$ .

FIG. 21. Radial section through the exterior and glebal tissues of *Truncocolumella rubra*.  $\times 42.5$ .

FIG. 22. Spores of *T. rubra*.  $\times 825$ .

FIG. 23. Spores of *T. citrina*.  $\times 825$ .

FIG. 24. Radial section through peridial and glebal tissues of *Dendrogaster olivaceus*.  $\times 42.5$ .

FIG. 25. Spores of *D. olivaceus*.  $\times 825$ .

FIG. 26. Radial section through peridial and glebal tissues of *Hydnangium setigerum*.  $\times 42.5$ .

FIG. 27. Spores of *H. setigerum*.  $\times 825$ .

FIG. 28. Radial section through peridial and glebal tissues of *Rhizopogon Thaxteri*.  $\times 42.5$ .

FIG. 29. Spores of *R. Thaxteri*.  $\times 825$ .

FIG. 30. Radial section through peridial and glebal tissues of *Melanogaster macrocarpus*.  $\times 42.5$ .

- FIG. 31. Spores of *M. macrocarpus*.  $\times 825$ .  
FIG. 32. Radial section through peridial and glebal tissues of *Hysterangium Darkeri*.  $\times 42.5$ .  
FIG. 33. Spores of *H. Darkeri*.  $\times 825$ .  
FIG. 34. Radial section of the peridium and gelatinous tramal peridium of *Calvarula excavata*, with one cortical suture dividing the gelatinous layer.  $\times 42.5$ .  
FIG. 35. Spores of *C. excavata*.  $\times 825$ .  
FIG. 36. Spores of *Gastrosporium simplex*.  $\times 825$ .  
FIG. 37. Spores of *Melanogaster luteus*.  $\times 825$ .  
FIG. 38. Spores of *M. Parksii*.  $\times 825$ .  
FIG. 39. Spores of *M. mollis*.  $\times 825$ .  
FIG. 40. Spores of *M. ambiguus*.  $\times 825$ .  
FIG. 41. Spores of *M. rubescens*.  $\times 825$ .  
FIG. 42. Spores of *M. tuberiformis*.  $\times 825$ .  
FIG. 43. Spores of *M. durissimus*.  $\times 825$ .  
FIG. 44. Spores of *M. variegatus*.  $\times 825$ .  
FIG. 45. Spores of *M. eurypermus*.  $\times 825$ .  
FIG. 46. Spores of *M. Broomeianus*.  $\times 825$ .  
FIG. 47. Spores of *M. intermedius*.  $\times 825$ .  
FIG. 48. Spores of *Secotium diminutivum*.  $\times 825$ .  
FIG. 49. Radial section through the peridium, gelatinous tramal peridium and a portion of the gleba of *Protophallus brunneus*. One of the cortical plates (sutures) is included.  $\times 42.5$ .  
FIG. 50. Spores of *P. brunneus*.  $\times 825$ .  
FIG. 51. Spores of *P. jamaicensis*.  $\times 825$ .  
FIG. 52. Radial section through the peridium, gelatinous envelope and a portion of the gleba of *Gelopellis macrospora*.  $\times 42.5$ .  
FIG. 53. Spores of *G. macrospora*.  $\times 825$ .  
FIG. 54. Spores of *G. Thaxteri*.  $\times 825$ .

## BITZEA, A NEW GENUS IN THE PUCCINIACEAE<sup>1</sup>

E. B. MAINS

In 1936 the writer obtained two collections of rust on species of *Inga* in the El Cayo District of British Honduras.<sup>2</sup> These possessed abundant telia containing sessile, one-celled, colorless, thin-walled teliospores. Associated in one of the collections were pycnia with circinating uredinia, the urediniospores irregularly reticulated with prominent longitudinal ridges. The uredinia resembled the primary uredinia of *Ravenelia Ingae* (P. Henn.) Arthur as described in North America Flora (3). Although pycnia, primary and secondary uredinia have been described for *R. Ingae*, telia are unknown. The question therefore arose whether the telia of the British Honduran specimens were connected with the uredinia. If so the rust would not be a species of *Ravenelia*.

These questions necessitated a study of collections of *Ravenelia Ingae* and other rusts of *Inga*. Through the kindness of Dr. George B. Cummins the collections of the Arthur Herbarium have been available for study. Dr. Cummins had noted the occurrence of one-celled teliospores on a number of these specimens and he very generously has allowed me to use his notes.

Forty-three collections of rust on species of *Inga* have been studied. Of these 15 have borne telia containing one-celled, hyaline teliospores. Of these 13 have been associated with uredinia of the type described as primary uredinia for *Ravenelia Ingae*. This therefore indicated that these are stages of one species and that it has been erroneously placed in the genus *Ravenelia*.

The study also raised another question. Secondary uredinia have been described (3) for *Ravenelia Ingae*. It is stated that these deform the shoots and are confluent in large irregular

<sup>1</sup> Papers from the Department of Botany and the Herbarium of the University of Michigan.

<sup>2</sup> This expedition was mostly supported by funds from the Horace H. Rackham School of Graduate Studies of the University of Michigan.

patches on the leaves. The spores are described as smaller than the primary urediniospores and echinulate.

Of the 43 collections studied 12 have pycnia and primary uredinia only; 12, pycnia, primary uredinia and telia; 3, pycnia, primary uredinia, and secondary uredinia; 1, pycnia, primary uredinia, secondary uredinia, and telia; and 15, secondary uredinia only. In the collection having pycnia, primary uredinia, secondary uredinia, and telia, the telia are more closely associated with the primary than with the secondary, the latter occurring mostly on different leaves. One would expect that in a species having primary and secondary uredinia that the telia would be most commonly associated with the secondary uredinia. Here the telia occur almost entirely in association with primary uredinia. This indicates that the secondary uredinia belong to a separate species. At least it would seem best to so consider them until telia have been found associated so that they can be definitely placed. Such a treatment raises a question concerning the specific name applicable to each.

*Uredo Ingae* was described by Hennings (7) from collections of *E. Ule* from Brazil. Hennings states that the uredinia cause a deformation of the branches, shoots, and fruits. A portion of the type (*Ule 1591*) has been available for study. The urediniospores are ellipsoid or obovoid,  $14-16 \times 18-24 \mu$ , the wall  $1.5-2 \mu$ , thickened at the apex,  $2-4 \mu$  and moderately echinulate. This rust is similar to the secondary uredinia described under *Ravenelia Ingae* in the North American Flora.

*Uromyces ingicola* was described by Hennings (8) from a collection of *Ule (2929)* on *Inga* sp. from Rio Juruá, Brazil. Hennings described verrucose urediniospores and one-celled, colored teliospores which had the wall longitudinally striate. Only a fragment of the type has been available for study. It bears a few uredinia apparently associated with pycnia. The urediniospores are similar to those described for the primary uredinia under *Ravenelia Ingae*. They are somewhat variable in markings and thickening of the wall at the apex and at the base. Hennings' teliospores were without question urediniospores. However, teliospores occur on the type. They are old and most have germinated. They are one-cell, hyaline, smooth and very thin-walled. An-

other collection collected by Puttemans (646) on *Inga* sp. at Sao Paulo, Brazil and reported by Hennings (9) as *Uromyces Ingicola* has furnished more satisfactory material. The urediniospores are obovoid,  $16-20 \times 20-30 \mu$ , the walls irregularly reticulated with the longitudinal ridges most prominent. Telia also occur on this specimen. The teliospores are sessile, clavate-cylindric,  $11-16 \times 70-90 \mu$ , the wall hyaline, very thin.

*Uredo excipulata* was described by the Sydows in 1904 from one of Pringles' collections of *Inga Inicuil* from Mexico. This apparently was taken from a phanerogamic specimen. According to the diary of Pringle published by Helen Burns Davis (6) a collection of *Inga Inicuil* (8134) was made April 13, 1899, at Jalapa. Dr. W. R. Maxon has very kindly examined this collection in the United States National Herbarium and has sent me several leaves bearing the rust. This agrees with a portion of the type in the Arthur Herbarium. The uredinia form circles around the pycnia. The urediniospores are obovoid,  $16-18 \times 24-38 \mu$ , the wall  $2 \mu$ , thickened at the apex,  $3-6 \mu$ . The markings of the urediniospores differ somewhat from those of *Uromyces ingicola*. They are poorly developed, occurring as short broken lines mostly on the upper and lower portions of the spores, the equatorial zone generally being smooth. Telia were not found on either specimen.

In 1907, Arthur (1) transferred *Uredo Ingae* to *Ravenelia* citing *Uredo excipulata* as a synonym. However, only pycnia and uredinia were described. Apparently the transfer was based on the prevalence of species of *Ravenelia* with somewhat similar uredinia on species of the Leguminosae. The Sydows (15) in their monograph accepted this and when in 1921, H. Sydow (11) proposed a division of *Ravenelia* into eight genera, he transferred *Ravenelia Ingae* to *Haploravenelia*.

*Uromyces porcensis* was described by Mayor in 1913 from a collection on *Inga* (cf) *ingoides* from the Dept. of Antiagua in Colombia. He described pycnia and teliospores. This collection has not been available for study but it is evident from Mayor's description and figures that the teliospores were urediniospores of the primary uredinial type.

*Ravenelia Whetzelii* was described by Arthur (2) in 1917 from collections of rust on *Inga vera* made by Whetzel and Olive in



Puerto Rico. Only pycnia and uredinia were described. The uredinia of the type (206) are in circles around the pycnia. The urediniospores are  $18-26 \times 31-42 \mu$ , the walls  $2.5-3 \mu$  thickened at the apex  $5-6 \mu$  and some at the base, and very strongly irregularly reticulated with the longitudinal ridges most prominent. No telia were found. One collection (207) cited by Arthur has in addition to pycnia and uredinia of the type described, secondary uredinia of the type of *Uredo Ingae*. Another collection (208) bears telia in addition to pycnia and primary uredinia. The teliospores are clavate-cylindric,  $14-20 \times 100-130 \mu$ , sessile, the wall hyaline and very thin.

Arthur (2) in his discussion of *Ravenelia Whetselii* states that a collection on *Inga pachycarpa* from Quito, Ecuador in 1892 distributed by G. Lagerheim under the unpublished name of *Uromyces Ingae* is also *R. Whetselii*. An examination of this collection shows pycnia, primary uredinia, and telia similar to those of collection 208.

In 1925, Arthur (3) redescribed *Ravenelia Ingae*. Pycnia, primary and secondary uredinia were described and it is stated that telia are unknown.

One-celled, hyaline teliospores have been described for two rusts of *Inga*, *Maravalia Ingae* Sydow, and *Maravalia utriculata* Sydow, *Maravalia Ingae* was described in 1925 by Sydow from collections of F. L. Stevens made in British Guiana (715, type) and Trinidad (790). Only telia were described and the teliospores are given as one-celled, hyaline, thin-walled and pedicellate. A study of the portions of these collections from the Arthur Herbarium and the Herbarium of the University of Michigan shows that the teliospores are sessile, clavate-cylindric,  $16-20 \times 90-110 \mu$ , hyaline, very thin-walled. These teliospores therefore agree very closely to those which have been found with the primary uredinia described under *Ravenelia Ingae*. This has been substantiated through the discovery of uredinia. One group of uredinia was found on a portion of the type collection received from the Farlow Herbarium through the kindness of Dr. David H. Linder. Uredinia were also located on portions of the Trinidad collection received from the University of Illinois through the kindness of Dr. Neil E. Stevens, and from Pathological and

Mycological Collections of the United States Bureau of Plant Industry through the kindness of Mr. John A. Stevenson. The urediniospores are broadly obovoid to ellipsoid,  $16-22 \times 26-32 \mu$ , the walls  $2 \mu$ , thickened up to  $5 \mu$  at the apex, irregularly longitudinally rugose with the ridges somewhat broken and with occasional somewhat indistinct crossridges.

*Maravalia utriculata* was also described in 1925 by Sydow from a collection (279) from Costa Rica on *Inga* sp. Only telia were described. A portion of this collection from the Arthur Herbarium has been available for study. The teliospores are similar to those of *Maravalia Ingae*. Uredinia also were found on this collection and the urediniospores agree with those found in collections of *M. Ingae*.

It is evident that *Maravalia Ingae* and *M. utriculata* are names applied to the telial stage of a rust which has pycnia and primary uredinia of the type first described under the name *Uromyces ingicola*. However, the genus *Maravalia* is based on *Maravalia pallida* Arth. which has teliospores with well developed pedicels. In this respect the rust under discussion is more closely allied with species of *Chrysocelis*. The genus *Chrysocelis* is based on *Chrysocelis Lupini* Lagerh. & Dietel which has pycnia, aecia, and telia. The pycnia are subepidermal, the aecia with catenulate spores but without a peridium and the teliospores sessile, hyaline and thin-walled. The *Inga* rust has a very different primary stage, uredinia with pedicellate spores. This is a difference in life cycle which is not generally accepted as a generic distinction. However, the subcuticular pycnia of the *Inga* rust justify an establishment of a new genus for the species.

Excluding, *Uredo Ingae* for the reason previously given, the species has been described under the following names arranged in chronological order. *Uromyces Ingicola* Henn., *Uredo excipulata* Sydow, *Uromyces porcensis* Mayor, *Ravenelia Whetzelii* Arth., *Maravalia Ingae* Sydow, and *Maravalia utriculata* Sydow. According to article 57 of the International Rules of Nomenclature (5), a species of the Uredinales must bear the earliest specific name which has been given, starting with Persoon's Synopsis, to the state containing the form which it has been agreed to call the perfect form. The perfect state for the Uredinales is

defined as that which ends in the teleutospore or its equivalent. There has been some difference of opinion concerning what constitutes the perfect state. Arthur (4) would interpret it as the sporophytic state in which case specific names based on secondary uredinia (uredia) would be valid. It is evident from the examples cited in the International Rules that it was not intended that uredinial names should take precedence over those applied to the telial stage.

The rust under discussion has been described twice in the genus *Uromyces* as *U. ingicola* and *U. porcensis*, teliospores supposedly being described for both. In both instances these were primary urediniospores. It has been described once as a species of *Ravenelia*, *R. Whetzelii*. Telia were not described, only pycnia and primary uredinia. For *Uredo excipulata* only pycnia and primary uredinia were described. Therefore even according to Arthur's interpretation of the International Rules these names would be excluded because they were applied to a spore form belonging to the gametophytic state. Telia were described and the name *Maravalia Ingae* published in *Mycologia* November 1, 1925, and under the name *M. utriculata* in *Annales Mycologici* December 31, 1925. The former therefore determines the specific name.

The following arrangement is proposed.

**Bitzea<sup>3</sup> gen. nov.**

Pycnia subcuticularia; uredinia subepidermalia; urediniosporae pedicellatae; telia subepidermalia; teliosporae inter se liberae, sessiles, hyalinae, statim germinantes.

**Bitzea Ingae (Sydow) comb. nov.**

*Uromyces ingicola* P. Henn. *Hedwigia* 43: 157. 1904.

*Uredo excipulata* Sydow, *Ann. Myc.* 2: 350. 1904.

*Uromyces porcensis* Mayor, *Mém. Soc. Neuch Sci. Nat.* 5: 459. 1913.

*Ravenelia Whetzelii* Arth., *Mycologia* 9: 64. 1917.

*Uromyces Ingae* Lagerh. ex. Arth., *Mycologia* 9: 65. 1917.

<sup>3</sup> The Indian name bitze is used for *Inga edulis* in some parts of the American tropics.

*Maravalia Ingae* Sydow, Mycologia 17: 257. 1925.

*Maravalia utriculata* Sydow, Ann. Myc. 23: 314. 1925.

Pycnia amphigenous, mostly epiphyllous, crowded in small groups, subcuticular, discoid, 100–200  $\mu$  across, 24–35  $\mu$  thick.

Primary uredinia amphigenous, crowded, surrounding the pycnia often forming a more or less continuous circle, subepidermal, deep seated in somewhat hypertrophied tissue, partially covered by the overarching tissue leaving only a slit, pulverulent, cinnamon-brown; urediniospores somewhat variable in size and markings, broadly obovoid or ellipsoid, 14–26(30)  $\times$  (20)24–48(55)  $\mu$ , the wall cinnamon-brown, 2–4  $\mu$ , more or less thickened at the apex 3–8  $\mu$ , sometimes thickened at the base, usually rugose-reticulated, the somewhat irregular longitudinally ridges prominent and the cross ridges less pronounced, in a few collections with ridges broken and even disappearing from the equatorial portion, the germ pores 3–4, equatorial.

Telia hypophyllous, white, small, 0.1–0.5 mm. and sometimes confluent, usually crowded in small groups, sometimes scattered, subepidermal; teliospores sessile, clavate or clavate-cylindric, 12–20  $\times$  70–140  $\mu$ , the wall hyaline, very thin, 0.5  $\mu$ , germinating at once.

The following specimens have been examined.

*Inga edulis* Mart. San Felipe, Guatemala, Jan. 14, 1917, E. W. D. Holway, 719, also *Uredo Ingae*; El Cayo, British Honduras, June 16, 1936, E. B. Mains, 3508.

*Inga Inicuil* Cham. & Schlecht. Jalapa, Mexico, Pringle (type of *Uredo excipulata*); Jalapa, Mexico, April 13, 1899, C. G. Pringle, 8134 (from phanerogamic specimen 342857 in the United States National Museum, probably same as the preceding).

*Inga insignis* H. B. K. Valle Chiche, Quito Ecuador, Sept. 2, 1920, E. W. D. & Mary M. Holway, 962.

*Inga laurina* (Sw.) Willd. El Junque, Puerto Rico, April 14, 1916, Whetzel and Olive, 209; Maricao, Puerto Rico, March 24, 1916. Whetzel and Olive, 210.

*Inga leptopoda* Benth. San Jose, Costa Rica, Jan. 8, 1916, E. W. D. Holway, 389, also *Uredo Ingae* and Jan. 10, 1916, 400; San Jose, Costa Rica, Feb. 1924, Paul C. Standley, 33287, also *Uredo Ingae*.

- Inga pachycarpa* Benth. Quito, Ecuador, Jan. 1892, G. Lagerheim (*Uromyces Ingae* Lagerh. ex. Arth.); Ambato, Ecuador, Abelardo Pachano, 25.
- Inga pinetorum* Pittier, San Agustin, British Honduras, Aug. 13, 1936, E. B. Mains, 4133.
- Inga Preussii* Harms. San Salvador, Salvador, March 30–April 24, 1922, Paul C. Standley, 22461.
- Inga vera* Willd. El Gigante near Adjuntas, Puerto Rico, July 16, 1915, F. L. Stevens, 8509; Maricao, Puerto Rico, March 25, 1916, H. H. Whetzel & Edgar W. Olive, 205; Mayaguez, Puerto Rico, H. H. Whetzel & Edgar W. Olive, 206 (type of *Ravenelia Whetzelii* Arth.); Maricao, Puerto Rico, Whetzel & Olive, March 23, 1916, 207, also *Uredo Ingae* and March 24, 1916, Whetzel & Olive 208; Rio Prieto, Puerto Rico, June 20, 1924, Whetzel, Kern, Toro, 2185, 2401 and July 7, 1924, 2384.
- Inga* sp. Rio Juruá, Brazil, June, 1901, Ule 2929 (type of *Uromyces ingicola* Henn.); Sao Paulo, Brazil, Puttemans, 646; San Jose, Costa Rica, Dec. 26, 1915, Holway, 295; Pinheiros, Sao Paulo, Brazil, March 27, 1922, E. W. D. & Mary Holway, 1684; Altoda Serra, Brazil, June 14, 1922, E. W. D. & Mary Holway, 1968; Vreedon Hoor, British Guiana, Jan. 8, 1922, F. L. Stevens, 715 (type of *Maravalia Ingae* Sydow); Coverden, Trinidad, Aug. 12, 1922, F. L. Stevens, 790; La Caja near San Jose, Costa Rica, Sydow 279 (type of *Maravalia utriculata* Sydow).

Secondary uredinia may rarely be produced. A few were noted which apparently were not associated with pycnia. These contained urediniospores which were similar to those of the primary uredinia. Some collections differed considerably from the average in urediniospore size and markings. At one extreme are collections with urediniospores measuring  $20-30 \times 40-55 \mu$ , with very pronounced rugose-reticulations. And at the other, collections with urediniospores measuring  $16-18 \times 24-33 \mu$ , with markings poorly developed and often missing in the equatorial zone. *Uredo excipulata* Sydow is in the latter group. Although this is a considerable difference, there are collections showing various gradations between these extremes and it seems best to consider them as one species.

It is difficult to obtain accurate measurements of the teliospores. Apparently as soon as they reach full size they germinate and collapse. Others take their place. As a result the telia are made up of a mass of collapsed teliospores and spores in various stages of development.

As already stated the secondary uredinia of the type of *Uredo Ingae* Henn. are excluded. They may possibly be the secondary uredinia of *Bitzea Ingae* but the evidence appears to be against it. It seems best to list collections of this type under the name of *Uredo Ingae* until telia are found definitely associated. This rust may be described as follows.

UREDIO INGAE P. Henn. Hedwigia 38 (69): 1899

*Ravenelia Ingae* Arth. N. Am. Flora 7: 132. 1907.

*Haploraavenelia Ingae* Sydow, Ann. Myc. 19: 165. 1921.

Uredinia caulicolous causing considerable deformation, on the leaves usually developing as large effused patches; urediniospores ellipsoid or obovoid,  $13-19 \times 18-26 \mu$ , the wall  $1.5-2 \mu$  somewhat thickened at apex,  $3-6 \mu$ , echinulate, the pores 3-4, equatorial.

*Inga edulis* Mart. Chinautta, Guatemala, Feb. 12, 1916, Holway 486; San Felipe, Guatemala, Jan. 14, 1917, Holway, 719, also *Bitzea Ingae*; Rio de Janeiro, Brazil, Aug. 13, 1921, E. W. D. & Mary Holway, 1031, Rel. Holw. 269.

*Inga leptopoda* Benth. San Jose, Costa Rica, Jan. 8, 1916, Holway, 389, also *Bitzea Ingae*, and Jan. 17, 1916, 486; San Jose, Costa Rica, Feb. 1924, Paul C. Standley, 33287, also *Bitzea Ingae*.

*Inga Preussii* Harms. San Salvador, Salvador, S. Calderon, Arth. Herb. No. 44614.

*Inga vera* Willd. Ponce, Puerto Rico, Aug. 1904, O. W. Barrett; Monte Montosa, Puerto Rico, Oct. 13, 1912, F. L. Stevens, g 76, and Oct. 14, 1912, 28 d; Monte Alegrillo, Puerto Rico, June 20, 1913, F. L. Stevens, 2376; Maricao, Puerto Rico, March 23, 1916, Whetzel & Olive, 207, also *Bitzea Ingae*; Adjuntos, Puerto Rico, July 15, 1924, Whetzel, Kern & Toro, 2371; Ciales Road, Puerto Rico, Whetzel, Kern & Toro, 2372; Maricao-Mayagues Road, Puerto Rico, July 8, 1926, Whetzel,

Kern & Toro, 2376; San Cristobal, Puerto Rico, March 4, 1926,  
Kern & Toro, 90.

*Ingæ* sp. St. Cathar. Blumenau, São Francisco, Brazil, E. Ule,  
1591 (type of *Uredo Ingæ* Henn.); Petropolis, Rio de Janeiro,  
Brazil, Dec. 20, 1921, E. W. D & Mary M. Holway, 1235.

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## SOME FUNGI IMPERFECTI FROM THE PACIFIC NORTHWEST<sup>1</sup>

RODERICK SPRAGUE<sup>2</sup> & WM. BRIDGE COOKE<sup>3</sup>

(WITH 2 FIGURES)

The fungi discussed or described in this article were collected either on Mt. Shasta, Siskiyou County, California, or in western Oregon. Specimens are deposited in the Mycological Herbarium of the Department of Botany at Oregon State College, Corvallis, Ore. Portions also have been deposited in the Mycological Collections of the Bureau of Plant Industry, U. S. Department of Agriculture, Washington, D. C. All of the collections bear the Oregon State College numbers and those collected on Mt. Shasta have, in addition, the collector's numbers.

### RAMULARIA DELPHINII Jaap

A fragmentary collection from Mt. Shasta (O. S. C. 8349, W. B. Cooke 8574) on *Delphinium pauciflorum* Nutt. was made in the chaparral at an elevation of about 5,000 feet, July 9, 1937. The fungus caused gray-white, sub-circular lesions which macroscopically resembled lesions due to downy mildew. The spores measured  $15-25 \times 5-7 \mu$  thus corresponding to Jaap's measurements ( $10-35 \times 4-7.5 \mu$ ). The type of *R. Delphinii* Jaap was found in the Swiss Alps at an elevation of 1,200 meters (3,900 feet). It was described by Jaap in 1913 (4) two years before *R. Delphinii* Dearness and House (3) was described, and there-

<sup>1</sup> Coöperative investigations by the Division of Cereal Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture, and the Department of Botany, Oregon Agricultural Experiment Station, Corvallis, Oregon. Published as Technical Paper No. 284 of the Oregon Agricultural Experiment Station.

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fore the latter species was renamed *R. Sheldoni* Trotter (8). The spores of *R. Sheldoni* measure  $15-33 \times 4-5 \mu$ .

Dr. House has very kindly furnished material of *R. Delphinii* Dearn. and House for comparison with the Shasta material. The lesions on the latter are, as mentioned, gray and downy while the former has arid, light tan lesions with distinct brown borders. Since the material of *R. Delphinii* Dearn. and House had very few spores and the material from Shasta was downy with them, it is possible that the morphological difference as shown by symptoms may not be of great significance. Further material is needed to show whether *R. Sheldoni* Trotter (*R. Delphinii* Dearn. and House) is distinct from *R. Delphinii* Jaap. The Shasta material at least, is clearly referable to *R. Delphinii* Jaap.

It is of interest to note that there are two other species of *Ramularia* described on *Delphinium* that may be synonyms of Jaap's fungus: *Ramularia albowiana* Siemaszko which was described in 1919 (9) has spores measuring  $20-42 \times 5-7 \mu$ . It was found in the Caucasus region. *R. brevipes* Sacc. has slightly smaller spores ( $20-28 \times 4-5 \mu$ ) and it is stated by Saccardo (7) that this species is very distinct. The entire group needs study where type material is available.

RAMULARIA SENECTIONIS (Berk. & Br.) Sacc. var. CARNIOLICA  
Jaap

A collection of a leaf spot on *Senecio lugens* Rich var. *exaltus* Gray on Mount Shasta (O. S. C. 8479, 8480, W. B. Cooke 8584) is referable to the above name. The spores measure  $18-33 \times 4.3-5.5 \mu$  (FIG. 1, A), as compared with  $25-40 \times 4-7 \mu$  for the conidia from Jaap's varietal type. *R. Senecionis* (Berk. and Br.) Sacc. is said to have smaller spores ( $13-22 \times 3-4 \mu$ ) which are sometimes septate.

An examination of prepared sections of the material from Mt. Shasta shows that the prominent conidiophores of the fungus continue to aggregate forming a definite acervulus-like growth which is eventually pushed out and partially replaced by spherical compact fruiting bodies. These appear to be immature and from their content are probably immature perithecia. These bodies are very numerous, prominent and scattered in the outer periphery

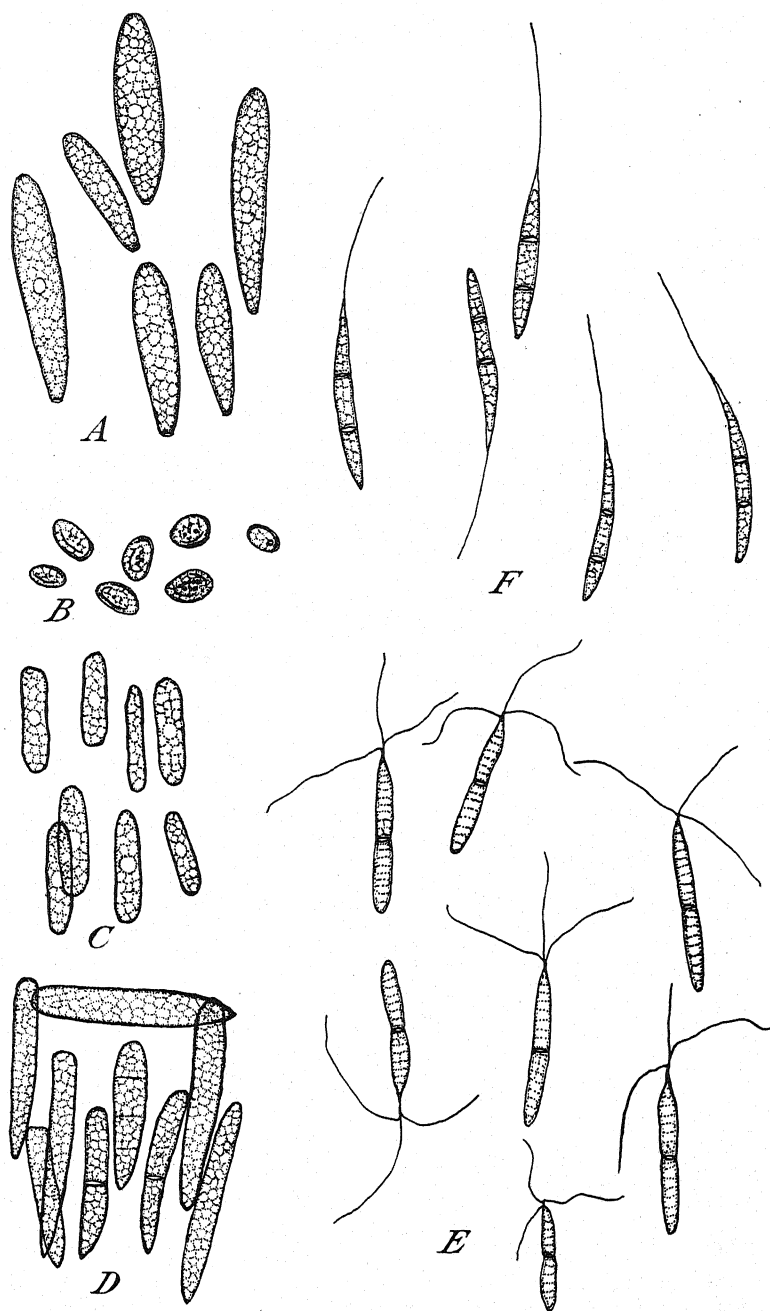


FIG. 1.

of the lesions. The same bodies are noted in material collected by C. L. Shear (924) at Telluride, Colorado (West American Fungi, 332).

The collection from Mount Shasta is similar to *Gloeosporium Senecionis* Ellis and Ev., *G. Senecionis-cordati* Allescher as well as a number of species of *Ramularia* described on *Senecio*. Without available type material for comparison the fungus is tentatively assigned to Jaap's variety, but its affinity with both *Gloeosporium* and *Ramularia* is considered worthy of note.

***Naemosphaeria shastensis* Sprague & W. B. Cooke, sp. nov.**

Pycnidiis conspicuis, gregariis, globosis, erumpentibus-superficialibus, rosetto brevi cylindrico, nigris, ostiolatis, contextu parenchymatico densissimo,  $250-360 \times 300-450 \mu$ ; pycnosporulis numerosis, ellipticis v. ovoideis v. subglobosis, brunneis,  $3-3.4 \times 4.5-6.5 \mu$ .

Hab. in foliis et culmis emortuis *Streptanthi tortuosi* Kellogg var. *orbiculati* Hall.

Pycnidia conspicuous, gregarious, globose, erumpent-superficial, with a short, cylindrical beak, ostiolate,  $250-360 \times 300-450 \mu$  diam., context densely parenchymatous. Pycnospores numerous, elliptical to ovoid to subglobose, brown  $3-3.4 \times 4.5-6.5 \mu$  (FIG. 1, B).

On dead leaves and stalks of *Streptanthus tortuosus* Kellogg var. *orbiculatus* Hall. Type: O. S. C. 8351, W. B. Cooke 8542, Mt. Shasta, Calif., June 28, 1937; O. S. C. 8346, W. B. Cooke 8589, Mt. Shasta, Calif., July 20, 1937.

The fungus is confined to plants growing in springy places and was found as soon as the snow had melted. The pycnidia, which arise from the epidermis, are large and prominent with a distinct cylindrical, sometimes eccentric, beak. Cross sections of the pycnidia disclose a great mass of small, light-brown spores (FIG. 1, B) surrounded by the rindlike, relatively thin, cell wall of the pycnidium. In crushed mounts the pycnidia float free as shells analogous to the way perithecia of the Erysiphales behave on being crushed.

***Placosphaeria shastensis* Sprague & W. B. Cooke, sp. nov.**

Stromatibus non maculiculis, dispersis vel rarius gregariis, leptothyrioideis, ellipticis v. irregularibus,  $150-350 \times 200-1,000 \mu$  diam.; loculis variabilibus,

plus minusve confluentibus, subglobosis v. irregularibus, contextu carbonaceis, nigris; sporophoris hyalinis,  $11-16 \times 2 \mu$ ; sporulis bacillaribus rectis, apice rotundatis, hyalinis,  $9-14 \times 2.5-4 \mu$ .

Hab. in caulibus emortuis *Monardellae odoratissimae* Benth. Mt. Shasta, California, June 24, 1937. Type: O. S. C. 8472, W. B. Cooke 8509.

Stroma not in spots, dispersed or less often gregarious, leptothyrioid, elliptical to irregular,  $150-350 \times 200-1,000 \mu$  in diameter, locules variable, more or less confluent, subglobose to irregular, context carbonaceous, black; sporophores hyaline,  $11-16 \times 2 \mu$ ; spores straight bacillar or cylindric, apices rounded or semi-squared, hyaline,  $9-14 \times 2.5-4 \mu$  (FIG. 1, C).

This fungus occurs on old overwintering stems of *Monardella odoratissima* Benth. at an elevation of 8,000 feet at Horse Camp. The fungus is associated with *Pleospora permunda* M. C. Cooke and *Stemphylium* sp.

#### MACROPHOMA CYLINDROSPORA (Desm.) Berl. & Vogl.

Punctiform pycnidia are abundant on dead and necrotic leaves of *Phlox Douglasii* Hook. collected on Mt. Shasta at an elevation of 8,000 feet (O. S. C. 8459, W. B. Cooke 8553) in midsummer, 1937. The spores are similar to those in the illustration of *M. cylindrospora* given by Grove (1) although many of them vary from the paliform cylindrical-truncate form in Grove's illustration. In addition, a few spores are one-septate and others give indication of becoming eventually three septate. However, most of the spores have clear, nonguttulated contents (FIG. 1, D). They measure  $17-22 \times 2.7-4.5 \mu$  thus slightly exceeding the measurements as given for *M. cylindrospora* which, however, appears to be a polymorphic species. This is the first report of the fungus on *Phlox*, one of the few reports of it on a semi-herbaceous plant, and possibly the first report from western America.

#### Robillarda Agrostidis Sprague, sp. nov.

Maculis diffusis, pycnidiis subcutaneis, sparsis, nigris, ostiolatis, globosis v. lenticularibus,  $160-200$  ( $60-450$ )  $\mu$  diam. Pycnosporulis cylindraceis, rectis, utrinque attenuatis, basi rotundatis, medio 1-septatis,  $17.5-20 \times 2.6-3.3 \mu$ , apice acutatis, 3-4 setaceis; setis  $8-15 \times \pm 0.5 \mu$ .

Hab. in foliis et vaginis dejectis, *Agrostidis tenuis*.

Pycnidia scattered, at first covered by the epidermis, later pseudosuperficial, black-brown, obscurely ostiolate, easily crushed

and the brittle thin shell consisting of polygonal, deeply pigmented, black-brown cells. Pycnidia extremely variable, as small as  $60\ \mu$  in diam., mostly  $160\text{--}200\ \mu$ , occasionally extremely elongate,  $450 \times 100\ \mu$ . Pycnospores  $17.5\text{--}20 \times 2.6\text{--}3.3\ \mu$ , hyaline, cylindric, moderately to not constricted at the single central septum, ends tapering, base rounded, tip acute tapering into a whip-like cilium which branches into three, rarely four, forks about  $1\ \mu$  from the end of the cell. Cilia nearly equal in length to the main body of the spore (FIG. 1, E).

On dead, straw-colored leaves and sheaths of *Agrostis tenuis* Sibth., Corvallis, Benton Co., Oregon. Type: O. S. C. 42, R. Sprague, Jan. 3, 1938.

**Heteropatella alpina** (Ellis & Ev.) W. B. Cooke, comb. nov.

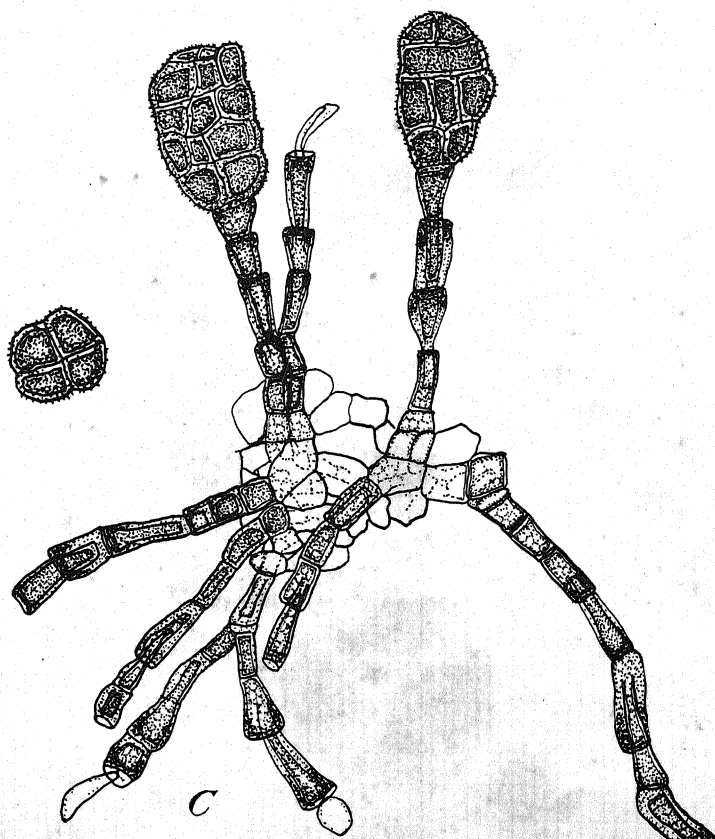
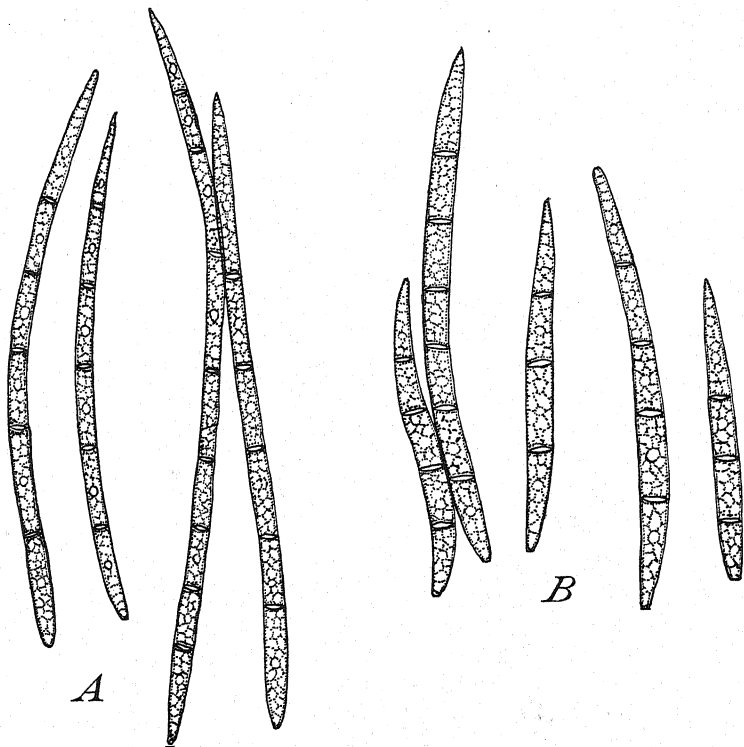
Fungi referable to the above combination were collected on *Juncus* sp. (W. B. Cooke 9305) and on *Ligusticum Grayi* (W. B. Cooke 8585) in the Panther Creek Heather Meadows on Mount Shasta at an elevation of 8,000 feet.

The spores, which measure  $32\text{--}45 \times 2.4\text{--}3.5\ \mu$ , including an apical prolongation  $\frac{1}{3}\text{--}\frac{1}{2}$  their total length (FIG. 1, F), are borne in subsuperficial excipuliform pycnidia. According to Grove (2) these characters place the fungus in the genus *Heteropatella*.

The material from Mt. Shasta appears to be virtually identical with *Kellermannia alpina* Ellis and Ev. described originally on *Aquilegia coerulea* and other herbaceous plants at an elevation of 12,000 ft. in the Colorado Rockies, but in the same Merriam (6) life zone (Hudsonian) as where the Shasta specimens were collected.

*Heteropatella alpina* differs from *H. Bonordenii* (Hazl.) Lind in having narrower spores, with blunt broad bases, and its spores are borne on shorter, stouter, branched conidiophores, and asci are lacking among the conidiophores. *H. alpina* differs also from *H. umbilicata* (Pers.) Jaap in that the spores of the former have 2–3 septa while those of the latter have uniformly three septa.

The Shasta material differs from *Kellermannia alpina* only in the more robust fruiting bodies (up to  $540\ \mu$ ) and slightly longer spores. However, the fungus is apparently somewhat variable. The writer prefers Grove's classification and transfers the fungus



to *Heteropatella*. Further study, with abundant material, may show, as Grove suggests, that we are dealing with a polymorphic species.

***Septoria Chlorogali* (M. C. Cooke & Harkness) Sprague,  
comb. nov.**

The fungus *Rhabdospora Chlorogali* M. C. Cooke and Harkness was collected on *Camassia Leichtlinii* Wats. near Irish Bend, Oregon (O. S. C. 8269). The pycnosporos measured  $24-31 \times 1.5-2.6 \mu$ . The fungus is a species of *Septoria* and the above combination is proposed.

**SEPTORIA MARGARITACEA Peck (Emended)**

A collection of *Septoria* on *Anaphalis margaritacea* (L.) B. and H. made at Waldport, Lincoln Co., Ore., had spores measuring  $29-55 \times 2.4-3.5 \mu$  (FIG. 2, B) and therefore appeared distinct from the description of *S. margaritacea* Peck which is listed with distinctly narrower spores measuring  $40-80 \times 1-2 \mu$ . However, a comparison with the type material from White Lake, N. Y., kindly furnished by Dr. H. D. House, disclosed spores broader than given in the type description. They measured  $40-77 \times 2-2.7 \mu$  (FIG. 2, A). The description is therefore emended to conform with the fragment of type material seen and to the material collected in Oregon. Fundamentally the Oregon material was similar to that from New York, the difference being only in length of spores.

Spots emarginate, ochraceous, becoming chestnut brown in the center, 0.5-2 cm. long. Pycnidia more or less numerous, epiphyllous, black, ostiolate, obscurely erumpent,  $90-250 \mu$  in diam. Pycnosporos broadly filiform, 3-9 septate, curved to straight, commonly attenuate at apex and obtuse at base,  $29-80 \times 2-3.5 \mu$ .

On living and dying leaves of *Anaphalis margaritacea* (L.) B. and H. White Lake, New York. Material collected at Waldport, Oregon, July 26, 1937 (O. S. C. 8410), used in emended description. The Oregon material was the same as that of the type fragment except that the spores were shorter and broader ( $29-55 \times 2.4-3.5 \mu$ ) and 3-6 septate (FIG. 2, B).

**Macrosporium rosarium** Penzig var. **Piscariae** Sprague,  
var. nov.

Maculis raris, rotundatis, isabellinis, griseis, epiphyllis margine angusto; hyphis fasciculatis, simplicibus, adscendentibus, 5-10 septatis, 50-105  $\times$  6-10.5  $\mu$ , brunneis, ad septa inflatis, cellis pyriformibus vel urniformibus; conidiis acrogenis, forma et magnitudine variis, muriformibus, multiseptatis, ad septa plus minusve constrictis; episporio crasso, granuloso-echinato, brunneo-olivaceis, 14-40  $\times$  15-23  $\mu$ .

Hab. in foliis vivis *Piscariae setigerae* (Hook.) Piper.

Spots few, round, isabelline, gray, epiphyllous, margin narrow; conidiophores fascicled, simple, ascending, 5-10 septate, 50-105  $\times$  6-10.5  $\mu$ , brown, cells of conidiophores inflated at septa, successively growing from the inner base of the previous lower cell, cells varying from pyriform to urn-shaped or nearly cylindrical. Conidia acrogenous, varying from nearly spherical to barrel-shaped, muriform and more or less constricted at the septa; major cross walls usually three, semi-deciduous from distal cell of conidiophore, partly tearing away from the endospore wall of distal cell from which the spore is separated by a late forming cross wall. Conidia brown-olive, minutely and thickly echinulate, 15-40  $\times$  15-23  $\mu$  (FIG. 2, C).

On living leaves of *Piscaria setigera* (Benth.) Piper. South of Mary's River, Corvallis, Benton Co., Type: Ore. O. S. C. 10,916, H. S. Jackson, Sept. 20, 1914.

This fungus is close to *Macrosporium rosarium* Penzig which is found on leaves of *Citrus limonum* in Italy. *M. rosarium* var. *Piscariae* differs in the longer couplings between the joints of the remarkably articulated conidiophores (FIG. 2, C), but, based on the description and the illustrations by Penzig (5), the writer fails to see how it differs sufficiently to warrant erecting a distinct species, notwithstanding the distinctly different hosts.

The writers are indebted to A. G. Johnson and Edith K. Cash of the Bureau of Plant Industry, U. S. Department of Agriculture, for kindly aid in the preparation of the manuscript.

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#### EXPLANATION OF FIGURES

All figures magnified  $\times 1,000$  except as noted.

FIG. 1. A, Conidia of *Ramularia Senecionis* var. *carniolica* on *Senecio lugens* var. *exaltus*. Mount Shasta (O. S. C. 8479); B, Pycnosporos of *Naemosphaeria shastensis* (Type); C, Pycnosporos of *Placosphaeria shastensis* (Type); D, Pycnosporos of *Macrophoma cylindrospora* on *Phlox Douglasii*. Mt. Shasta, Calif. (O. S. C. 8459); E, Pycnosporos of *Robillarda Agrostidis* (Type); F, Pycnosporos of *Heteropatella alpina* on *Juncus* sp. Mt. Shasta (W. B. Cooke No. 9305).

FIG. 2. A, *Septoria margaritacea* on *Anaphalis margaritacea* from White Lake, N. Y. (Type); B, *S. margaritacea* on *A. margaritacea*, Waldport, Ore. (O. S. C. 8410); C, *Macrosporium rosarium* var. *Piscariae* (Type). Conidiophores bearing conidia ( $\times 500$ ).

## OBSERVATIONS ON THE RATE OF GROWTH OF ASCOCARPS OF PEZIZA DOMICILIANA

S. M. PADY

During the past winter months ascocarps of a *Peziza* have appeared from time to time on the floor of a room in our residence. The mycelium was growing in the wood in a small section kept continually moist by the sweating of adjacent cold water pipes. The surface of the wood was slowly rotting, forming an ideal substratum for the growth and development of the fungus. The area in which the fruiting bodies were observed was a narrow strip about 12 inches long and  $\frac{1}{2}$  an inch or less in width, terminated by an open space about  $1\frac{1}{2}$  inches square, and bounded on one side by linoleum and on the other by a porcelain fixture. Although the ascocarps appeared only in this strip, the area invaded by the mycelium is probably more extensive since the moisture supply, while not large, was fairly constant and apparently adequate for the needs of the fungus. The number of mature ascocarps was usually small, ranging from one to four. As will be shown in Table I below, many young ascocarps appeared but very few managed to survive; in this case the food supply was probably the limiting factor. The temperature remained fairly high throughout the winter, the minimum being about  $60^{\circ}$  and the maximum about  $80^{\circ}$ . One window facing east supplied light, but since this opened onto a screened porch only a small amount of light reached the fungus. Ascocarps were first noticed in the fall of 1937 and continued to appear during the winter and spring. Whether or not fruiting bodies had appeared prior to this could not be determined. Commencing in January daily observations were made and records kept of (1) the total number of ascocarps and (2) the daily growth of maturing individuals. The fungus appears to be *Peziza domiciliana* Cooke, and agrees closely with Seaver's description.<sup>1</sup>

<sup>1</sup> Seaver, F. J. The North American Cup-Fungi, p. 230. 1928.

TABLE I  
TOTAL NUMBER OF YOUNG AND MATURING ASCOCARPS

Date	No. Asco-carp	Remarks	Date	No. Asco-carp	Remarks
Jan. 20/38	11	All young	Mar. 14	4	(One dead)
Jan. 21	12	(One new)	Mar. 17	3	(One dying)
Jan. 23	5	(Remainder degenerated)	Mar. 21	6	(3 new ones)
Feb. 4	4	All mature by Feb. 7	Mar. 22	7	(1 new one)
Feb. 14	18	All very young	Apr. 11	5	3 later removed
Feb. 15	12	Young stages dying	Apr. 19	6	All later removed
Feb. 16	2*	One new one	Apr. 24	4	All later removed
Mar. 12	5	All small	May 4	6	

\* Development of one of these given in Table II.

In Table I some of the observations of the total number of ascocarps in the field are given. Numerous young stages appeared about the same time; very few however, reached maturity. This is clearly shown in the series from Jan. 20 to Feb. 4. Of the 12 original ascocarps only four matured, one on Feb. 2, the others on Feb. 7. A second crop of young ascocarps then appeared on Feb. 14; subsequently all except one degenerated. Sometimes new individuals appear after the first main group, as for example on Feb. 16 when a new one appeared, but these usually degenerated also. On March 12 five additional ascocarps appeared, of which three went on to reach maturity about March 25. New ones appeared on March 21 and March 22, but these died in a few days. A survey of the field on April 11 showed five young stages; three of these were removed for study. Eight days later a new crop of six appeared, all of which were likewise removed. As a result, a second crop of four appeared five days later. This area thus produced a fairly regular succession of young stages, of which only a small number ever reached maturity.

Of the group of eighteen ascocarps appearing on Feb. 14 only one reached maturity. The daily development of this individual is shown in Table II. At first (Feb. 14) this ascocarp was more or less cylindrical in outline, but during the next two days the base gradually increased to about twice the diameter of the upper portion. Soon, however, the rapidly growing apothecium obscured the base, which became the stem. Growth was fairly uniform except on Feb. 18 when the increase was more rapid, due probably to an increase in the temperature of the room. The apo-

TABLE II  
RATE OF GROWTH IN MILLIMETERS OF A SINGLE ASCOCARP

Time of Observation	Diameter			Height of Asco-carp	Daily Increase	
	Apothecium	Opening (Hymenium)	Base		Apothecium	Opening
Feb. 14, 10:00 P.M.	1½-2	—	—	—	—	—
Feb. 15, —	2	—	—	—	1	—
Feb. 16, 10:00 P.M.	3	—	6	—	1	—
Feb. 17, 10:00 P.M.	4	—	7	10+	1	—
Feb. 18, 10:00 P.M.	7	3	—	—	3	—
Feb. 19, 11:30 P.M.	8-9	4½	—	—	1½	1½
Feb. 20, 10:30 P.M.	10	6	—	—	1½	1½
Feb. 21, 10:30 P.M.	13	9	—	—	3	3
Feb. 22, 10:30 P.M.	17	13	—	—	4	4
Feb. 23, 10:30 P.M.	20	17	—	25	3	4
Feb. 24, 10:30 P.M.	25	22	—	26	5	5
Feb. 25, 10:15 P.M.	31	28	—	26	6	6
Feb. 26, 12:30 A.M.	45 × 42*	—	—	—	11-14	—
Feb. 28, 6:00 A.M.	60 × 45	—	—	—	13-15	—
Feb. 28, 10:30 P.M.	66 × 50	—	—	—	5-6	—
Mar. 1, —	75 × 50	—	—	—	5-9	—
Mar. 2, —	Preserved	—	—	—	—	—

\* Apothecium became repand.

thecium retained its typical cup-shaped appearance until about the eleventh or twelfth day at which time it became repand and the diameter then increased tremendously. No observation was made at the regular hour on Feb. 27, but a measurement was taken at 6:00 A.M. on Feb. 28. At 10:30 P.M. the same day the ascocarp showed an increase in diameter of 5-6 mm. The mature ascocarps were typical with entire margin, often splitting, convex, umbilicate, hymenium dingy buff to brownish, stem yellowish-white.

The length of time required by the ascocarp shown in Table II to reach the mature condition was 16 days from the date of the first observation. In five other cases the length of time was 22, 27, 18, 16, 17 days respectively, the average length of all six being 20 days. Since nothing is known of the early stages of development or of the time required for these early stages it may be assumed that the total length of time required is somewhat longer. From these preliminary observations it is clear that under the above growing conditions *Peziza domiciliana* required about 20 days to complete its development and reach maturity.

# CONTRIBUTION TO KNOWLEDGE OF THE GENUS *TAPHRINA* IN NORTH AMERICA<sup>1</sup>

W. WINFIELD RAY<sup>2</sup>

(WITH 23 FIGURES)

This investigation was undertaken with the hope that critical study of some of the American species of *Taphrina* would contribute toward the ultimate preparation of the evidently much needed monograph of this important genus. Work was begun in 1936, and during its progress practically every American and European species has been examined. In this paper observations on some of the North American species occurring on *Alnus* and *Prunus* are presented.

Whenever possible fresh material has been employed for examination, but dried specimens, numbering over 500 in the Cornell University Herbarium, have been used also, especially for supplementary study. The writer has collected in abundance material of 12 valid species in the vicinity of Ithaca, New York. Many cultures have been made, 22 species having been obtained from fresh material collected by the author or forwarded by workers in other states.

The writer adopts the procedure of Giesenhagen (1895) in placing in the genus *Taphrina* all species formerly included in *Exoascus*, *Taphrina*, and *Magnusiella*. The genus *Magnusiella* as earlier proposed by Giesenhagen consists of species which later were transferred to the Protomycetaceae. The generic interpretations of *Exoascus*, *Taphrina*, and *Magnusiella* made by Sadebeck

<sup>1</sup> A portion of a thesis presented to the faculty of the Graduate School of Cornell University in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

<sup>2</sup> The writer wishes to express his indebtedness to Professor H. M. Fitzpatrick, under whom this investigation has been prosecuted, for the suggestion that it be undertaken, and for the advice and encouragement during its progress. Thanks are due the many workers from other institutions for making available specimens for examination.

(1893), were based on the presence or absence of a perennial mycelium, and are not practical for use in making taxonomic separations. The author feels that no noteworthy characteristics have been set forth which justify the use of more than one genus. Therefore, all species are placed in the genus *Taphrina*.

#### SPECIES OF *TAPHRINA* ON *ALNUS*

*TAPHRINA ROBINSONIANA* Gies.: This species commonly occurs on the bracts of the female catkins of *Alnus incana* (L.) Moench. and *A. rugosa* (Ehrh.) Spreng. in the central and eastern portions of North America during the summer months. The invasion of the subcuticular regions of the bracts brings about a hypertrophic condition of these organs (FIG. 15). In the early stages of infection the bracts are yellowish-green, later becoming yellowish-red or red.

The literature concerning *T. Robinsoniana* is scanty, in part because it is distinctly a North American species. In the monographic works of Robinson (9) and Patterson (7) the species is incorporated, but not under this name. Since the fungus does not occur in Europe, it is seldom mentioned in European monographs. The names, *T. amentorum*, *T. Alni-incanae*, and *T. alnitorqua* are most often employed for it, but none of them is synonymous with *T. Robinsoniana*. Because of the absence of this name in American monographs, and because of the difficulty of obtaining satisfactory mounts for microscopic study, improper choice of a name for the species was inevitable.

Robinson (1887) described the fungus correctly, mentioning its distortion of the bracts of female catkins of *A. incana*. However, he called it *T. alnitorqua* Tul. (*T. Tosquinetii* (West.) Magnus), a species which in Europe causes "witches'-broom" of *A. incana* and *A. glutinosa* Gaertn.

Patterson (1895) chose to call the fungus *Exoascus amentorum* Sad., because she found "no stalk cells." She listed as *E. amentorum* one specimen of the species sent to her by Dr. Farlow. This particular specimen collected at Newton, Massachusetts, was undoubtedly a portion of the material issued by Ellis in N. Am. Fungi 296, and called *Ascomyces Tosquinetii* West. She failed to notice that it had a basal cell.

Giesenhagen (1895) studied Ellis' No. 296 and concluded that the fungus was not *T. amentorum* (Sad.) Rost., which does lack a basal cell, but was indeed a new species possessing a basal cell. He knew also that it was not *T. Tosquetii*. He named it *T. Robinsoniana* in honor of Robinson who had first described the fungus.

Examinations of numerous fresh and dried collections indicate that *T. Robinsoniana* is responsible for the catkin disease of *A. incana* and *A. rugosa* during the summer. In no case has *T. amentorum* been encountered on these hosts. The limits of the many asci measured are  $23\text{--}39\ \mu \times 7\text{--}11.5\ \mu$ . Basal cells are  $11.5\text{--}19\ \mu$  long  $\times 8\text{--}15\ \mu$  wide. Eight spored asci are common, although budding of the spores often results in a polysporic condition (FIG. 3).

In an alder swamp near Etna, New York, where *T. Robinsoniana* is common on the bracts of female catkins, two small collections of distorted, young shoots were made. The symptoms were manifested by a hypertrophic condition of the stem and leaves which had the yellowish to reddish color so common to infected catkin bracts. Microscopic examinations have demonstrated clearly that the fungus is *T. Robinsoniana*. The asci are smaller on the average than those from the diseased bracts, although the limits in size are nearly the same (FIG. 4). The results of many measurements show that the asci are  $23\text{--}36\ \mu \times 7\text{--}9.5\ \mu$ ; basal cells are  $8\text{--}15.5\ \mu$  long  $\times 8\text{--}13\ \mu$  wide. Isolates from diseased shoots are similar in every respect to those from diseased bracts.

SPECIMENS EXAMINED: Material from Canada, Nova Scotia, Massachusetts, Maine, Michigan, New York, and Wisconsin on *A. incana*; from Alabama, Delaware, Georgia, Virginia, and West Virginia on *A. rugosa*. The writer's herbarium contains 15 collections made by him in New York. In all, 40 specimens have been examined.

TAPHRINA AMENTORUM (Sad.) Rost.: For many years *Taphrina amentorum* has been known in Europe as the only species causing deformation of the bracts of female catkins of *Alnus incana* (L.) Moench. and *A. glutinosa* Gaertn. Since this fungus is so common in Europe, it has been thought that the species affecting aments of *A. incana* in North America is the same. As

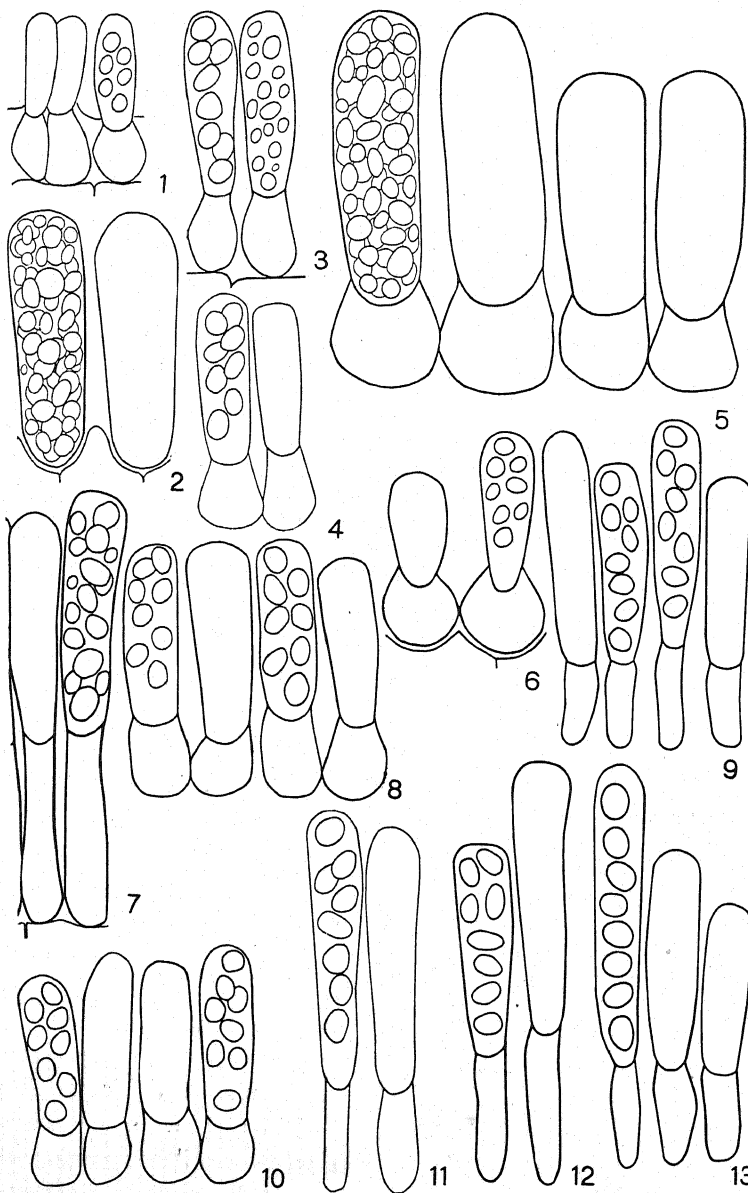
has been pointed out above, *T. Robinsoniana* is, however, the only species occurring on *A. incana* in North America.

A search for *T. amentorum* among various collections has failed to disclose it as the cause of a catkin disease in this country. It has been discovered, however, on the bracts of fertile catkins of *Alnus oregona* Nutt. in a collection made in Alaska in 1899 by B. E. Fernow. This specimen was found in the collection of *Alnus* in the phanerogamic herbarium of the Department of Botany at Cornell University. Since *A. oregona* also occurs in the northwestern area of the United States, one might expect to find the fungus in this country, but the writer has no knowledge of its occurrence here. The fungus produces the same hypertrophic symptoms on the bracts of fertile catkins of *A. oregona* as those produced by *T. Robinsoniana* on *A. incana* (FIG. 15). The asci (FIG. 2) in this collection are  $37-47\ \mu \times 10-12\ \mu$ . The asci are almost always polyspored.

Attempts at selection of the correct specific name for this fungus have long caused dispute. The writer feels that the matter should be settled, and to that end the history of the nomenclature of the species is outlined here. J. Kühn (1873) named a fungus deforming the bracts of fertile catkins of *Alnus* in Europe, *Exoascus alnitorquus* (Tul.) J. Kühn forma *Alni-incanae* Kühn in litt. His collection was issued in Rabenhorst, Fungi Europ. Exsic. XVII Cent. 1873, No. 1616. Berkeley and Broome (1876), without actually describing it, discussed a fungus causing a disease of the female catkins of alder and named it *Ascomyces Alni*. This specific name had been used by DeBary in 1869 for another *Taphrina* on the leaves of alder, and hence could not be used by them. Rostrup (1879) called a fungus he found on the aments of *Alnus*, *Ascomyces Tosquinetii strobilina*. Thümen<sup>3</sup> in 1880 also collected this fungus and named it *Exoascus Alni* De Bary var. *strobilinus*. The specimen was issued in Mycotheca univ. XIV. Cent. 1879, No. 1366. Sadebeck (1888), after making a microscopic study of the fungus, decided that it was an undescribed species and called it *Exoascus amentorum*. Although he gave no measurements of the asci, he pointed out that the ascus lacks a basal cell, a character which immediately separates it from all known forms

<sup>3</sup> Diagnosen zu Thümens "Mycotheca universalis." Flora 63: 325. 1880.





FIGS. 1, *Taphrina rugosa*; 2, *T. amentorum*; 3, 4, *T. Robinsoniana*; 5, *T. occidentalis*; 6, *T. media*; 7, *T. Atkinsonii*; 8, *T. confusa*; 9, *T. flavorubra*; 10, *T. Farlowii*; 11, 12, 13, *T. communis*.

of *Taphrina* on alder. Magnus (1890) maintained that the name applied by Sadebeck had no standing because of the varietal name used by Kühn. He examined Kühn's collection and found no basal cell. He proposed, therefore, the name *T. Alni-incanae* (Kühn) Magnus, the name most commonly used today. It seems to the writer that Magnus was not justified in rejecting the name used by Sadebeck, even though, as some point out, the Sadebeck diagnosis does not constitute a formal description. The absence of a basal cell clearly sets the species apart from all others occurring on alder, and Sadebeck recognized and mentioned this distinguishing feature. Saccardo (Syll. Fung. 10: 69) gives *E. Alni-incanae* Kühn in litt. as the correct name and places *E. amentorum* Sad. in synonymy. This name in the Sylloge has no standing, because a valid specific name already existed. In 1893 Sadebeck (14) gave an accurate description of this fungus and again called it *E. amentorum*. Rostrup (1890) accepted Sadebeck's name, but placed the species in the genus *Taphrina*. Therefore, the accepted name is *T. amentorum* (Sad.) Rost.

***Taphrina rugosa* sp. nov.**

Hymenio subcuticulari; mycelio interiore carente; ascis cylindraceis, in apice rotundatis vel paulo truncatis,  $14-28\ \mu$  longis  $\times 4.5-9\ \mu$  crassis, circa  $23 \times 7.5\ \mu$ ; cellula basalari plerumque ellipsoidea vel cylindracea,  $8-14\ \mu$  longis  $\times 6-10\ \mu$  crassis, circa  $10.5 \times 8\ \mu$ ; sporidiis octonis vel paucioribus, ellipsoideis vel ovoidis,  $2-4.5\ \mu$  diam.

DISTRIBUTION: Causing hypertrophy and deformation of the bracts of fertile catkins of *Alnus rugosa*. April and May. Georgia.

TYPE: In the herbarium of Department of Plant Pathology, Cornell University, No. 27346.

SPECIMENS EXAMINED: The writer's herbarium contains 2 collections in addition to one collection of co-type material from Georgia.

In every April of the past three years, Dr. W. A. Jenkins of Experiment, Ga., has supplied me with diseased catkins of *Alnus rugosa* (Ehrh.) Spreng. In this material the subcuticular region of the bracts of fertile catkins was found to be invaded by an undescribed species of *Taphrina* which was causing a hypertrophic condition (FIG. 14).

This disease occurs early in the season when the catkins are developed little more than in the previous autumn. The bracts of *A. rugosa* affected by this new species seldom exceed 5 millimeters in length. In the case of *T. Robinsoniana* on *A. incana* and *A. rugosa*, the disease does not appear until the catkins are nearly mature, and infected bracts become 2–3.5 centimeters long.

The asci (FIG. 1) in this Georgia material also are small compared with those of most known species of *Taphrina* affecting alder. They are cylindrical with the apices rounded to nearly truncate. The basal cells are ellipsoidal in shape, and the sides are rounded unless lateral pressure from adjacent basal cells makes them straight. The base is usually rounded but may be nearly pointed. The spores are ellipsoidal to ovoid, and the number in all of the asci examined is eight, or less than 8.

Isolates of this fungus and *T. Robinsoniana* have been compared in culture under various conditions. On solid potato-dextrose media, they appear identical. Their temperature relations are, however, not the same. Isolates from *A. rugosa* grow more vigorously at temperatures of 3° C. and 6° C. as one extreme, and at 27° C. as the other, than do those of *T. Robinsoniana*. At 30° C. isolates of the new species remain viable for 15 days, whereas isolates of *T. Robinsoniana* remain viable for only 10 days or less. At this temperature isolates of the former species become slimy, while those of the latter do not.

When the two fungi are grown in a series of synthetic media, cultures which contain various carbon sources, used one at a time, it is found that often they do not utilize the same foods.

On the basis of morphology, time of infection, and culture characteristics, the author feels that the fungus affecting bracts of female catkins of *A. rugosa* during the early spring in Georgia is a new species and is distinct from *T. Robinsoniana*. He proposes to call it *Taphrina rugosa*.

#### *Taphrina occidentalis* sp. nov.

Hymenio subcuticulari; mycelio interiore carente; ascis cylindraceis vel paulo clavatis, in apice rotundatis, 34–54  $\mu$  longis  $\times$  10–20  $\mu$  crassis, circa 38–46  $\times$  15  $\mu$ ; cellula basalari, latiore quam longa, ad basim rotundata vel complanata, interdum intra cellulas epidermicales paulo extendati, 8–17  $\mu$

alta  $\times 12\text{--}22\ \mu$  crassis, circa  $12 \times 17\ \mu$ ; sporidiis multis, sphaeroideis v. ellipsoideis,  $1.5\text{--}4\ \mu \times 2\text{--}6\ \mu$ .

DISTRIBUTION: Causing deformation and hypertrophy of bracts of fertile catkins of *Alnus oregona*, *A. rhombifolia*, and *A. tenuifolia* in western United States.

TYPE: In the herbarium of the Department of Plant Pathology, Cornell University, No. 10622.

SPECIMENS EXAMINED: Nine collections of material from California, Idaho, Montana, and Oregon on *A. oregona*, *A. rhombifolia*, and *A. tenuifolia* were examined and are in the writer's herbarium.

While engaged in the examination of herbarium specimens of diseased catkins of *Alnus*, an undescribed species was discovered on distorted bracts of fertile catkins of *Alnus oregona* Nutt. The specimen, No. 10622, in the herbarium of Department of Plant Pathology, Cornell University, was collected by J. A. Weir at Grants Pass, Oregon.

In the collection of *Alnus* in the herbarium of the Department of Botany at Cornell University, the same species was found on fertile catkins of *A. tenuifolia* Nutt. from Idaho and *A. rhombifolia* Nutt. from Oregon. Professor H. S. Jackson forwarded for study diseased catkins of *A. tenuifolia* from Montana, *A. rhombifolia* from California, and *A. oregona* from Oregon. Professor A. J. Mix sent collections made in California on *A. oregona* and in Idaho on *A. tenuifolia*. All show the same organism.

The diseased bracts are swollen, elongated, distorted, tongue-shaped, and red. The symptom picture is similar to that of the distorted bracts of *A. incana* affected by *T. Robinsoniana* (FIG. 15).

Although the fungus and *T. Robinsoniana* are alike in possessing a subcuticular mycelium and in the symptoms produced on their hosts, they are distinct morphologically. The new species has longer and broader asci than *T. Robinsoniana*. Its basal cells are as wide as they are long or even wider, a characteristic not common to *T. Robinsoniana* whose basal cells are almost always longer than wide.

The asci are cylindrical or slightly clavate and have rounded apices (FIG. 5). The basal cells never become inserted between

the epidermal cells to any extent. All asci observed contain numerous, ellipsoidal to sphaeroidal spores.

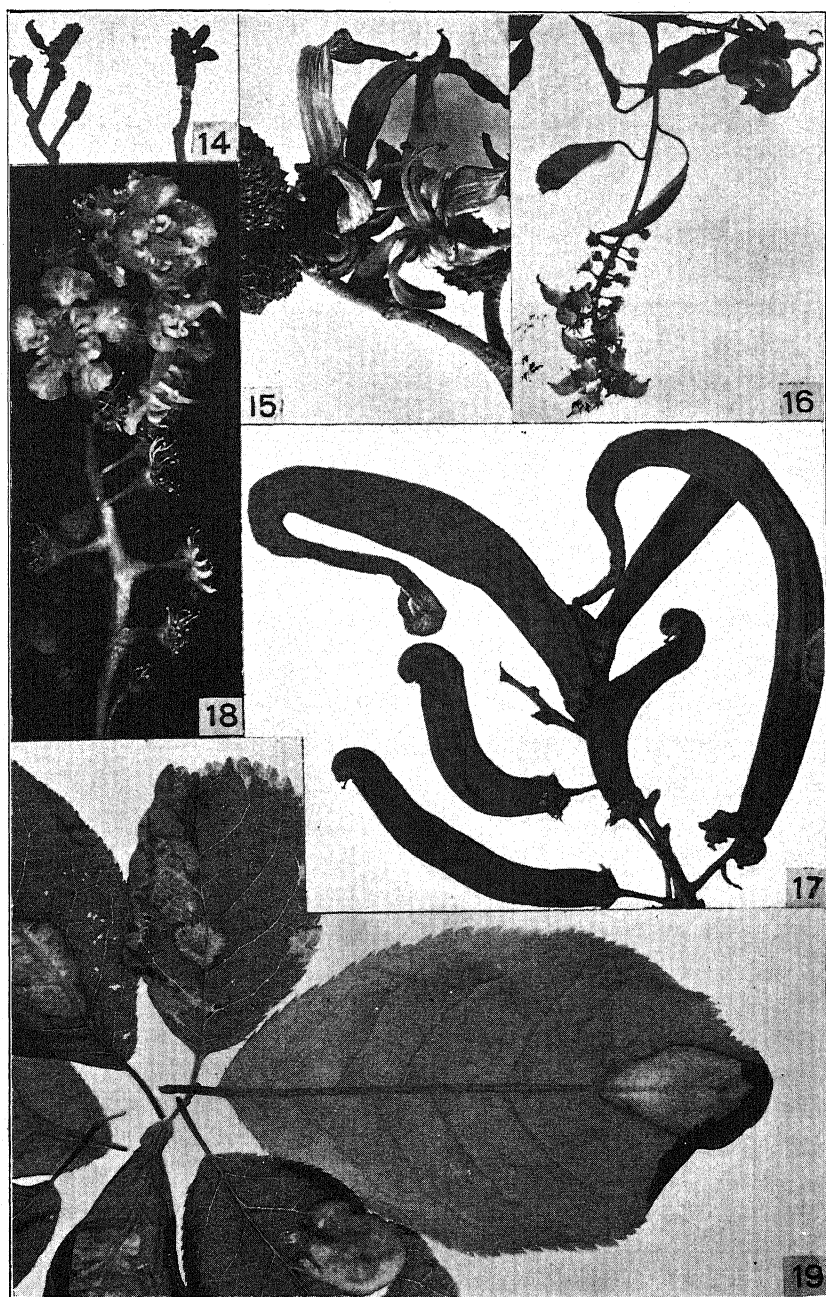
On the average, the asci and basal cells on diseased bracts of *A. oregona* are slightly larger than the same structures on *A. rhombifolia* and *A. tenuifolia* (FIG. 5). Because the limits in size of these structures are the same, and because the general morphology is similar in all collections, the writer, however, considers only one species of *Taphrina* as the cause of catkin disease of *Alnus* in western United States. Since the hosts are confined to that area, the author proposes the name *Taphrina occidentalis*.

**TAPHRINA MEDIA** Palm: A collection of leaves of *Alnus crispa* (Ait.) Purch. var. *mollis* Fern. affected by *Taphrina media* Palm was made June 26, 1929, by H. H. Whetzel and D. S. Welch near Hanover, New Hampshire. This fungus was described by Palm (1917) from a "witches'-broom" on *A. glutinosa* Gaertn. in Sweden. To the writer's knowledge this species has never before been reported in North America on any species of *Alnus*.

According to the collectors, a severe "witches'-broom" was not formed, but there was a tendency for the twigs to bend upward as in a typical "broom." Either the leaf was entirely affected by the fungus or only partially so. The margin of the leaf shows symptoms first, and by an invasion of the mycelium inward, the entire leaf becomes infected. Diseased areas are reddish-brown.

The length of the asci, according to Palm (6) is 25–90  $\mu$ . In his key to the species of *Taphrina* on *Alnus* the asci were reported, however, as 25–30  $\mu$  long. The latter measurements are correct, while the former represent apparently a typographical error. Saccardo (24: 1301–1302) repeated the typographical error.

Asci occur in the subcuticular regions on the upper and lower surfaces of the leaf. No vegetative mycelium exists in its interior. The asci (FIG. 6) are clavate with apices rounded or truncate, while the bases are narrowed and appear as if inserted into the basal cell. They are 19–27  $\mu$  long  $\times$  8–11  $\mu$  wide, the average size being 22  $\times$  9  $\mu$ . Basal cells are almost spherical, but often the width exceeds the length. The size of these cells is 10–12  $\mu$  long  $\times$  10–15  $\mu$  wide.



FIGS. 14, *Taphrina rugosa*; 15, *T. Robinsoniana*; 16, *T. Farlowii*; 17, *T. Atkinsonii*; 18, 19, *T. confusa*.

SPECIES OF *TAPHRINA* ON *PRUNUS****Taphrina Atkinsonii* sp. nov.**

Mycelio hymeniali subcuticulari; mycelio in spatiis intercellulariis abundante; ascis cylindraceutis vel clavatis, in apice rotundatis,  $38-45\ \mu$  longis  $\times$   $8-11\ \mu$  crassis, circa  $41 \times 10\ \mu$ ; cellulae basales cylindraceutae, ad basim rotundatae,  $28-40\ \mu$  longis  $\times$   $5-8\ \mu$  crassis, circa  $30 \times 7\ \mu$ ; sporidiis ellipsoideis vel globosis, octonis vel multis,  $2.5-5 \times 6-9\ \mu$ .

DISTRIBUTION: Causing deformation and hypertrophy of fruits and flower parts of *Prunus Capuli* in Mexico.

TYPE: In the herbarium of G. F. Atkinson which is filed as a unit in the herbarium of the Department of Plant Pathology, Cornell University, No. 21697.

A collection of a new species of *Taphrina* affecting the fruits and flower parts of *Prunus Capuli* Cav. was found in the Atkinson Collection in the herbarium of the Department of Plant Pathology of Cornell University. The specimens were collected by Edward Palmer in San Ramon, Durango, Mexico, in 1906. Although the fungus was designated as a new species by Atkinson and a typewritten description was found within the packet, he failed to publish his observations. Since a search of the literature by the writer has failed to disclose any species like it, publication of our findings seemed desirable.

Due to hypertrophy, the affected fruits become 3-15 centimeters long and 6-10 millimeters in diameter. They are hollow, usually curved, often strongly so, or coiled into a small hook toward the apex (FIG. 17). Apparently the style and perianth parts may or may not be deformed.

The asci are cylindrical to slightly clavate and have rounded apices (FIG. 7). The basal cells, which are nearly cylindrical, have a rounded base. The spores are ellipsoidal to globose, each ascus containing eight to many spores. Vegetative mycelium is abundant throughout the intercellular spaces of the affected host tissues.

In honor of Professor Atkinson, the writer proposes for the fungus the name, *Taphrina Atkinsonii*.

*TAPHRINA FARLOWII* Sad.: From diseased fruits of *Prunus serotina* Ehrh. collected by Dr. Farlow at Cambridge, Mass., Sadebeck

(1890) described a new species, *Taphrina Farlowii*. The affected ovaries and flower parts become hypertrophied and are persistent (FIG. 16). This new species was accepted by many investigators, including Atkinson (2), Giesenhagen (4), and Patterson (7).

Sadebeck gave the measurements for the asci as  $20-30\ \mu \times 8-9\ \mu$  and the basal cells as  $15-25\ \mu \times 8-9\ \mu$ . Patterson (7) and Atkinson (2) found the length of the basal cell in specimens examined by them to be shorter than reported by Sadebeck. The writer finds that the asci are  $20-35\ \mu \times 8-12\ \mu$  and the basal cells  $6-18\ \mu \times 8-12\ \mu$ .

Atkinson (1894) described a new species causing a hyperplastic disease of leaves and shoots of *P. serotina* and called it *Exoascus varius*. This species, it was pointed out, differs chiefly from *T. Farlowii* in that it causes a leaf disease, whereas, the latter species causes fruit and flower deformation. He says, "the two forms, the one on the fruit and the one on the leaves, were so common on the same tree and so closely associated that many times I have been strongly inclined to consider them one and the same species. This inclination has been strengthened by a study of the structures of the fungus, for in many cases the asci and stalk cells on the leaves are very much like those of *E. Farlowii* on the fruits." Disregarding the morphological facts, he chose to call the fungus on the leaves *E. varius*.

Giesenhagen (1895) made *E. varius* a synonym of *T. Farlowii*. He gave no explanation for this action, but on the basis of morphology only he was justified in relegating it to synonymy.

Examinations of asci and basal cells from many collections of dried and fresh material has convinced the writer that only one species of *Taphrina* is the cause of disease of *P. serotina* (FIG. 10). These structures taken from the fruits were found to be slightly longer than those from the leaves, but the limits in size for them are the same.

Isolates obtained from diseased fruits and leaves were found to be alike macroscopically on solid potato-dextrose media, and growth responses at various temperatures were the same for all. Growth was slow at  $0^{\circ}\text{C}$ . and  $3^{\circ}\text{C}$ .; at  $30^{\circ}\text{C}$ . there was no response, while at  $27^{\circ}\text{C}$ . the rate of growth was almost normal. Young, active cultures remained viable less than two weeks at  $30^{\circ}$



C. and for nearly 6 weeks at 27° C. Compared with many species of *Taphrina*, this fungus can not endure as high temperatures nor for so long a time.

Since the morphological and cultured characters of the fungi from fruits and leaves are identical, the writer recognizes only one species, *T. Farlowii*.

SPECIMENS EXAMINED: Material from Alabama, Delaware, Florida, Georgia, Kentucky, Massachusetts, North Carolina, and South Carolina has been examined.

*TAPHRINA CONFUSA* (Atk.) Gies.: Charles Peck (8) described a species of *Taphrina* which inhabited the leaves of *Prunus virginiana* L. and named it *Exoascus unilateralis*. The type specimen was collected at North Elba, Jefferson Co., New York, in 1897. He stated that the asci are always on the upper surface of the leaves and that their size is  $40\text{--}50\ \mu \times 13\text{--}16\ \mu$ , while the basal cells are isodiametric, measuring  $13\text{--}16\ \mu$ .

Examinations of a large number of specimens collected in the vicinity of Ithaca, New York, and Peck's collections listed as "Type I" and "Type II," have demonstrated clearly that asci commonly occur on both sides of the leaf and that their size is considerably smaller than stated in the original description. The writer finds that the asci are  $25\text{--}40\ \mu \times 8\text{--}12\ \mu$ , the average length being  $28\text{--}34\ \mu$ . The basal cells are usually longer than broad and measure  $8\text{--}16\ \mu \times 7\text{--}13\ \mu$ .

Lesions, which are convex above and concave below, vary in size from those no larger than a few millimeters in diameter to others involving the whole leaf (FIG. 19). Diseased areas become yellowish to bright-red and waxy in appearance. Large lesions cause the leaf to fold inward. Occasionally tender shoots become infected, but their leaves may remain healthy. Mycelium occurs abundantly in the intercellular spaces of the leaf parenchyma. Normal leaf thickness seldom exceeds  $140\ \mu$ , but in a lesion may reach  $500\ \mu$ .

*Taphrina confusa* (Atk.) Gies. causes a hypertrophic disease of flower parts of *P. virginiana*. The organ most commonly affected is the pistil which becomes swollen and elongated. In many cases the stamens, perianth, receptacle, pedicel, and peduncle also become infected (FIG. 18). All hypertrophied organs are tan to flesh-

colored. Diseased flowers and leaves commonly have been found together and in both instances the fungus develops and matures at exactly the same time. The obvious question to be answered is, "are there two species of *Taphrina* causing disease in *P. virginiana* or only one?"

Microscopic examinations of the fungi from the various diseased organs of many collections reveals that the asci and basal cells in all cases are similar (FIG. 8). In general, the average size of these structures from leaves is slightly smaller than those from fruits and flower parts. However, the limits in size for all is the same, and, on the basis of morphology, only one species should be recognized.

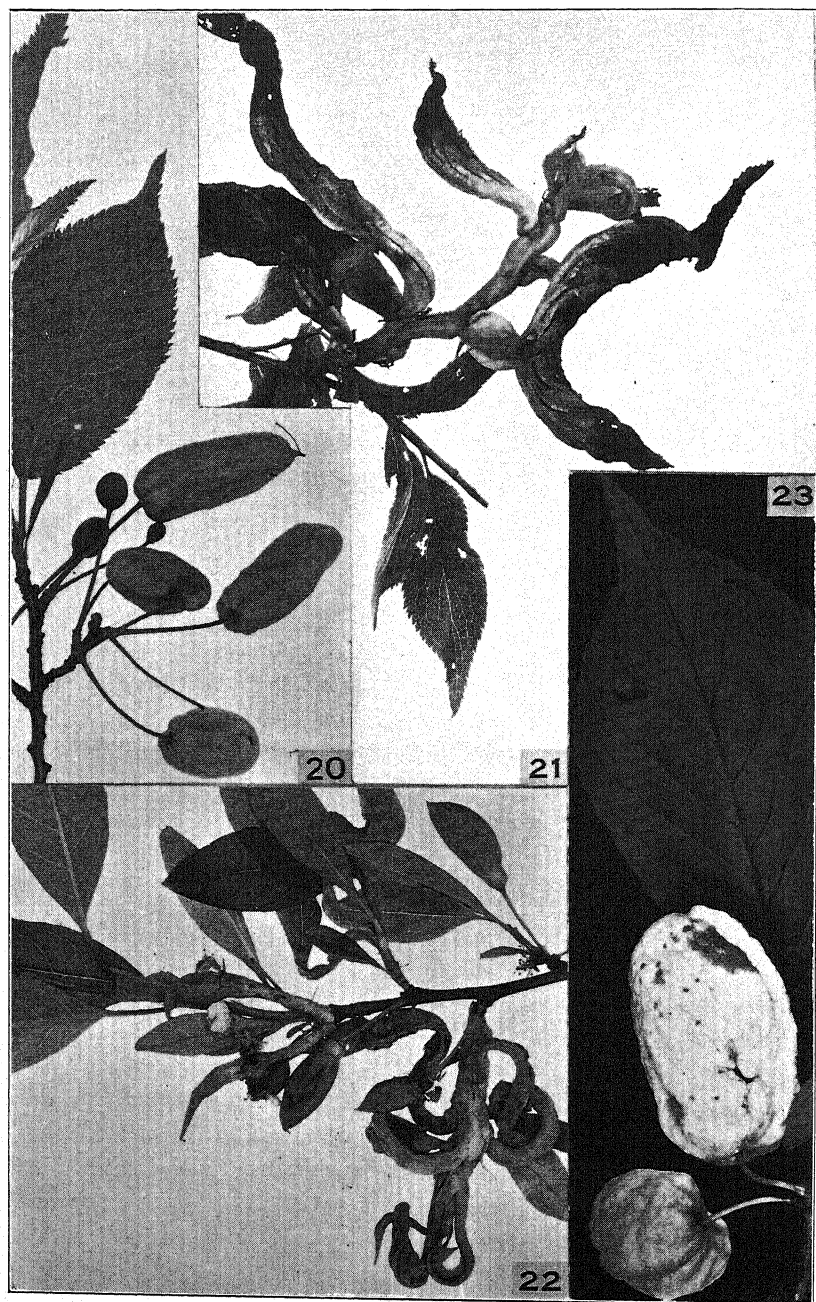
Numerous isolates have been obtained from diseased flowers and leaves, and all found alike in their response to extremes in temperature and in their ability to maintain life at high temperatures.

The rate of growth at 0° C. and 3° C. is not so rapid as for some other species of *Taphrina*. At 27° C. or higher, no growth takes place, whereas, isolates of twenty-one other species of *Taphrina* tested show growth. At 30° C. the isolates remain viable between 3 and 6 days and at 27° C. between 25 and 30 days. All other species of *Taphrina* tested maintain life longer than 30 days at 27° C., some for 6 months.

On the basis of morphology and cultural characteristics the writer feels that only one species is responsible for the disease of *P. virginiana*. Since *Exoascus confusus* was described by Atkinson (1) in 1894 and *E. unilateralis* by Peck (8) in 1898, the name applied by the former has priority. Giesenhagen (4) in 1895 placed Atkinson's species in the genus *Taphrina*, calling it *Taphrina confusa* (Atk.) Gies.

Though there exists certain morphologic similarities between *T. confusa* and *T. Farlowii*, the asci and basal cells of the former are on the average longer than those of the latter. On the basis of cultural characteristics, these two species are quite distinct.

*Taphrina Farlowii* is chiefly southern in its range and occurs commonly in the states south of Delaware. An intensive search for this fungus in New York has been unsuccessful, even though *P. serotina*, its host, is a common plant. *Taphrina confusa* on



FIGS. 20, 21, *Taphrina communis*; 22, *T. flavorubra*; 23, *T. communis*.

the other hand, has been found only in the northern states. A collection made by John Dearness in Canada and issued in Seymour and Earle, Econ. Fungi 467, as *E. Farlowii* on the ovaries of *P. serotina*, is *T. confusa* on the ovaries of *P. virginiana*.

The evidence presented convinces the writer that *T. Farlowii* and *T. confusa* are valid and distinct species.

SPECIMENS EXAMINED: Material from Canada, Michigan, and New York has been studied. The writer's herbarium contains 30 collections made by him near Ithaca, New York.

TAPHRINA COMMUNIS (Sad.) Gies.: In the vicinity of Ithaca, New York, *Taphrina communis* (Sad.) Gies. commonly causes "pockets" of *Prunus nigra* Ait. (FIG. 23) and *P. americana* Marsh. (FIG. 20). The size of the asci and basal cells (FIG. 11, 12) from diseased fruits of both hosts are as given by Sadebeck (1893). The basal cells, however, are slightly wider than originally described.

For the past two years the writer has collected infected shoots and fruits of *P. americana* in several plum thickets (FIG. 20, 21). Diseased fruits occurred chiefly on the larger shrubs and deformed shoots on the smaller. Occasionally tender shoots of the mature plants also were diseased.

Atkinson (1894) believed that the fungus on the leaves of *P. americana* differs from *T. communis* on the fruits and he named it *Exoascus decipiens*. He stated that the asci are  $20-40\ \mu \times 7-10\ \mu$ , and that the basal cells are  $6-13\ \mu$  long  $\times 7-12\ \mu$  wide. He wrote, "the young shoot is somewhat enlarged, though there are developed no asci on any of the shoots which I have seen."

An examination of the type specimen, collected at Danby, New York, near Ithaca, reveals that the asci and basal cells are as Atkinson described them. Asci are found only on the leaves and not on the shoots or petioles.

In several collections made by the author, asci were found on stems, petiole, and leaf-blade (FIG. 13). The asci from the stem and base of the petiole are  $37-49\ \mu \times 7-11\ \mu$ , and the basal cells are  $16-23\ \mu \times 3.5-8\ \mu$ . These dimensions approximate those of asci and basal cells from fruits. Asci from the base of infected leaf-blades are  $27-41\ \mu \times 7.7-11\ \mu$  and the basal cells  $11-17\ \mu \times 5-10\ \mu$ . Sections of leaves near the extreme limits of the my-

celial invasion, disclose smaller asci with wider and shorter basal cells than these same structures from stems, petioles, and fruits. The asci are  $23-35\ \mu \times 7-9\ \mu$ , and the basal cells are  $7-13\ \mu \times 7-12\ \mu$ . These measurements correspond with those given by Atkinson for *E. decipiens*. It is evident that asci and basal cells become smaller in size from the stem toward the outer extremities of infection in the leaf-blade.

Since *E. decipiens* was based on asci and basal cells from the leaf-blade, it is understandable that Atkinson should believe it to be different from *T. communis* on the fruits. However, in the light of the evidence presented, the writer feels that only one species is the cause of the disease of *P. americana*.

Isolates obtained from diseased fruits and shoots are alike as to color, consistency, and temperature relationships.

On the basis of the various facts and observations, *E. decipiens* is relegated to synonymy in favor of *T. communis*. The concept of *T. communis* must be expanded therefore to include the disease of shoots and leaves of *P. americana*.

SPECIMENS EXAMINED: Material on *P. nigra* from New York and on *P. americana* from Kansas, Montana, Nebraska, New York, and North Carolina has been examined. The writer's herbarium contains 10 collections made by him near Ithaca, New York.

### ***Taphrina flavorubra* sp. nov.**

Hymenio subcuticulari; mycelio interiore in spatii intercellulariis abundante; ascis cylindraceis vel clavatis, in apice rotundatis,  $20-40\ \mu$  longis  $\times$   $6-10\ \mu$  crassis; cellulae basales ad basim rotundatae vel acutae,  $8-16\ \mu$  altae  $\times$   $4-9\ \mu$  crassa; sporidiis octonis vel multis, ellipsoides,  $3-6 \times 2-4\ \mu$ .

DISTRIBUTION: Causing a hypertrophy of fruits, shoots, and leaves of *Prunus Susquehanae* in the United States.

TYPE: In the herbarium of the Department of Plant Pathology, Cornell University, No. 26425.

SPECIMENS EXAMINED: The writer has made 3 collections near Ithaca, New York, and has examined 7 other collections made in the same place in past years.

Atkinson (2) among other workers (4, 7, 14) believed *Taphrina communis* (Sad.) Gies. to be the cause of "pockets" of *Prunus*

*Susquehanae* Willd., although he stated that he had never seen the asci. Patterson (7), likewise failed to examine the asci on this host.

This plant grows abundantly in a small, confined locality near Ithaca, New York. In 1936 and 1938 diseased fruits were found, and in 1937 the disease was severe on both fruits and shoots. To the author's knowledge, hypertrophy of the shoots (FIG. 22) has never been reported in the literature.

Microscopic examinations of asci and basal cells from fruits and shoots disclosed only one species as the cause (FIG. 9). The asci and basal cells compared with those from the fruits of *P. americana* and *P. nigra* are decidedly shorter.

Asci from near the outer extremes of the mycelial invasion into the leaf were found to be shorter and the basal cells wider than those same structures from the fruit or stem. A similar observation was made in the case of *T. communis* on the shoots of *P. americana*.

*Prunus Susquehanae* is a member of the "cherry" division of *Prunus* and not of the "plum." Since nearly all species of *Taphrina* are specialized in their host relationships, it would be natural to expect that a species affecting plums would be unlikely to cause a disease of cherry.

The "pockets" produced are never as large in proportion as are diseased fruits of *P. nigra* and *P. americana*. The fruits become elongated and hollow, and often both ends taper, especially the distal one (FIG. 22). Ridges and furrows in the plane of the long axis are often present, and the infected fruits are bright-red, or yellowish-red. The shoots likewise when invaded by mycelium become yellowish-red. In contrast, fruits and shoots of *P. americana* affected by *T. communis* are white or yellowish.

Isolates obtained from diseased shoots and fruits were identical in every respect. When compared with isolates of *T. communis*, those from *P. Susquehanae* were found lighter in color, but all other characters tested were the same.

On the basis of the size of the asci and basal cells, the color and other symptoms of diseased tissues, and the host relationship, the writer believes that a species differing from *T. communis* is responsible for the disease of *P. Susquehanae*. He proposes to

call the fungus *Taphrina flavorubra*, a name referring to the yellowish-red color of the infected host tissues.

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#### EXPLANATION OF FIGURES

FIG. 1, asci of *Taphrina rugosa* from bract of fertile catkin of *Alnus rugosa* collected in Georgia; 2, asci of *T. amentorum* from bract of fertile catkin of *A. oregona* collected in Alaska; 3, asci of *T. Robinsoniana* from bract of fertile catkin of *A. incana*; 4, asci of *T. Robinsoniana* from diseased shoot of *A. incana*; 5, *T. occidentalis*, the two asci at the left from bract of fertile catkin of *A. oregona*, the two asci at the right from *A. rhombifolia*; 6, asci of *T. media* from leaf of *A. crispa* var. *mollis*; 7, asci of *T. Atkinsonii* from fruit of *Prunus Capuli*; 8, *T. confusa*, the two asci at the left from fruit of *P. virginiana*, the two at the right from leaf; 9, *T.*

*flavorubra*, the two asci at the left from shoot of *P. Susquehanae*, the two at the right from fruit; 10, *T. Farlowii*, the two asci at the left from leaf of *P. serotina*, the two at the right from fruit; 11, asci of *T. communis* from fruit of *P. nigra*; 12, asci of *T. communis* from fruit of *P. americana*; 13, *T. communis*, ascus at the left from shoot of *P. americana*, the two asci at the right from near the base of an infected leaf. All drawings  $\times 893$ .

FIG. 14, hypertrophied bracts of *Alnus rugosa* caused by *T. rugosa*, nat. size; 15, hypertrophied bracts of *A. incana* caused by *T. Robinsoniana*, nat. size; 16, diseased fruits and leaves of *P. serotina* caused by *T. Farlowii*, nat. size; 17, fruits and flower parts of *P. Capuli* deformed by *T. Atkinsonii*, nat. size; 18, hypertrophy of ovaries, petals, stamens, pedicels, and peduncle of *P. virginiana* caused by *T. confusa*,  $\times 1\frac{1}{2}$ ; 19, lesions on leaves of *P. virginiana* caused by *T. confusa*, nat. size; 20, diseased fruits of *P. americana* caused by *T. communis*, reduced  $\frac{1}{12}$ ; 21, deformed shoots of *P. americana* caused by *T. communis*, reduced  $\frac{1}{12}$ ; 22, hypertrophied shoot, leaves, and fruits of *P. Susquehanae* caused by *T. flavorubra*, reduced  $\frac{1}{10}$ ; 23, "pockets" of *P. nigra* caused by *T. communis*, reduced  $\frac{1}{4}$ .



# THE DERMATOPHYTE MICROSPORUM LANOSUM<sup>1</sup>

ELEANOR SILVER DOWDING & HAROLD ORR

(WITH 29 FIGURES)

## 1. CLINICAL OBSERVATIONS

*Microsporum lanosum* is capable of infecting the hair and the glabrous skin of animals and of human beings. In man it may produce ringworm of the scalp, ringworm of the body, and more rarely ringworm of the beard.

The chief fungi causing scalp ringworm are two, *Microsporum Audouini* and *M. lanosum*. *M. Audouini* produces non-inflammatory lesions which must be treated by epilation. *M. lanosum* commonly produces inflammatory lesions which may be cured by local applications of fungicides. However, in our survey of the dermatophytes of Alberta we have repeatedly isolated *Microsporum lanosum* from non-inflammatory scalp lesions. Therefore a mycological as well as a clinical study of the dermatophyte is necessary for diagnosis.

Cleveland, in British Columbia (2), cured 26 non-inflammatory tinea capitis cases (which he provisionally classified from their appearance, without cultural studies, as of the "human" type—i.e. *M. Audouini*) by local therapy alone. Since publishing his results, Dr. Cleveland very kindly sent us infected hairs from six of these patients with dry scaly lesions and one with suppurating lesions, all of which he had cured by local treatment. Seven cultures were obtained from this material and upon mycological examination they all proved to be *Microsporum lanosum*. The apparently anomalous reaction to Dr. Cleveland's treatment was therefore explained.

The non-inflammatory type of ringworm due to *M. lanosum* is in fact clinically indistinguishable from that due to *M. Audouini*.

<sup>1</sup> Contribution from the Provincial Laboratory, University of Alberta, Canada.

In culture, however, *M. lanosum* can be readily recognized by its more vigorous growth and more numerous spores.

## 2. MATERIAL AND METHODS

The species of dermatophytes are distinguished one from another in the saprophytic stage of their life history. For successful identification they must be grown on a medium which produces the minimum variation. Sabouraud's medium, which has been the standard substance for culture, produces variations in the fungus in response to slight unavoidable differences in the peptone constituent.<sup>2</sup>

Conant (3) testing a number of species of *Microsporum* on different media, obtained the least variation and the most abundant sporulation on rice. This medium has been used in the present investigation. Erlenmeyer flasks were filled with one volume of polished rice and three volumes of water, and sterilized by heating on three consecutive days without pressure. The flasks were then inoculated with infected hair or skin and kept at room temperature.

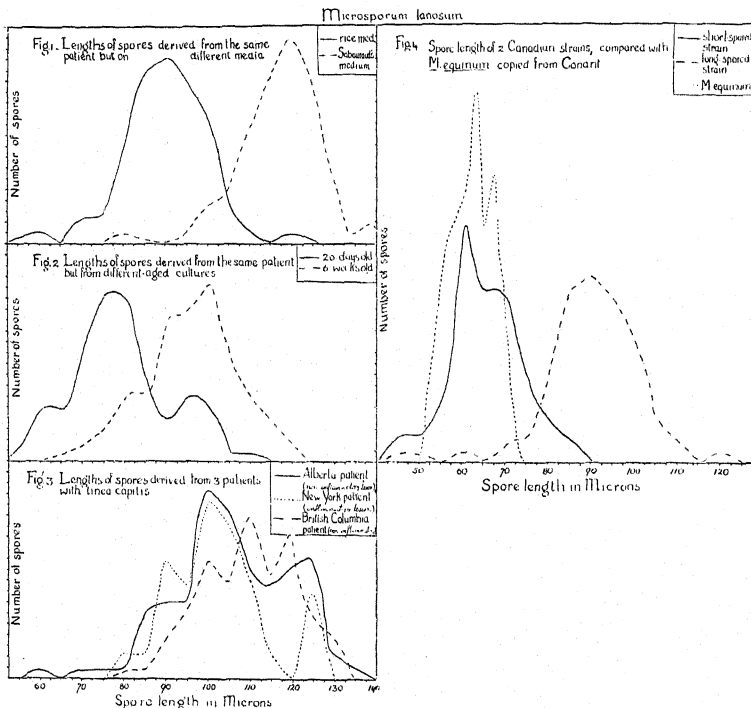
It is important to emphasize that the character of the mycelium of a dermatophyte varies with the composition of the medium and the age of the culture. This is illustrated by the following observations:

(1) Two cultures were used, both derived from the same patient, and of the same age, but one was grown upon rice and the other upon Sabouraud's medium. The lengths of one hundred macroconidia from each culture were measured and frequency graphs were constructed as shown in figure 1. The mean length of spores formed on rice is  $90\ \mu$  (with a standard deviation of  $10\ \mu$ ), and that of spores on Sabouraud's medium is  $119\ \mu$  (with a standard deviation of  $10\ \mu$ )—a difference of  $29\ \mu$ .

(2) Two cultures were used, both derived from the same patient, and grown on Sabouraud's medium, but one had been growing for 20 days and the other for 6 weeks. The lengths of one

<sup>2</sup> Plaut, and later Davidson and Gregory (7) have obtained saprophytic spore forms of several species by allowing them to grow out into the air from the original infected human tissue which is planted in damp chambers of determined humidity. Although this method dispenses with a variable medium, the "in situ" cultures are too small for some purposes.

hundred spores from each culture were measured and the resulting graphs are shown in figure 2. It may be seen that the mean length of spores of the old culture is  $79\ \mu$  (with a standard deviation of  $12\ \mu$ ), while that of spores of the young culture is  $95\ \mu$  (with a standard deviation of  $10\ \mu$ )—a difference of  $16\ \mu$ .



FIGS. 1-4.

Conant (5) in his paper on the taxonomy of the genus *Microsporium* uses the length of the macroconidium as a basis of diagnosis of species. Thus the difference between the mean spore length of two well-established species, *M. fulvum* and *M. lanosum*, is  $30\ \mu$ . Yet the above experiments show that spores from the same species will vary in length as much as  $29\ \mu$  under different conditions.

(3) When *Microsporium lanosum* is grown on rice at room temperature the culture passes through the following progressive changes:

At first the aerial mycelium is white and coarsely downy, producing few microconidia and no macroconidia. During the second week it becomes "pinkish-buff" and granular. This change is due to the production and shedding of large numbers of macroconidia. By the 20th day, tufts of fine, white downy "pleomorphic" growth appear here and there over the surface, subsequently spreading and covering the whole culture. Under dry conditions the white growth is sterile or almost sterile. With more moisture it produces large numbers of microconidia.

On Sabouraud's medium the progressive changes are slower, the maximum production of macroconidia being in the third week.

These three observations should make it clear that it is necessary to use identical conditions for comparable results. In the present investigation cultures were grown on rice (unless otherwise stated) at room temperature for two weeks, at which time the macroconidia production was at its peak.

Twelve strains of *Microsporum lanosum* were isolated from twelve patients, most of whom were residing in Alberta or British Columbia, and who were suffering from different types of ringworm.

The more important taxonomic characters of *Microsporum lanosum* are described by Conant (5) as follows:

"Colonies matted or cottony, white to 'pinkish buff' becoming powdery, coloring rice yellow; macroconidia  $54-94 \times 14-22 \mu$ , 2-10 septate, fusoid, warty or spinose, hyaline or light yellow, outer walls of median cells conspicuously thickened."

The spores germinate readily within 24 hours on corn-meal agar or rice. The microconidia swell and send out one or more germ-tubes from any part of the cell wall. The macroconidia send out germ-tubes from their two ends (FIG. 5). The extreme thickness of the lateral wall in this species probably makes lateral germination difficult. Only one spore was found among a hundred or so, in which a germ-tube broke through the lateral wall. On the other hand, when the thin-walled macroconidia of *Microsporum fulvum* germinate, the germ-tubes break out from every side of the spore (FIG. 6).

3. TWO CANADIAN STRAINS<sup>3</sup>

In order to verify the provisional classification of the cultures which by their gross characters resembled *Microsporum lanosum*, one hundred spores from each culture were measured.

*Widths.* The widths of the macroconidia are very variable. Figures 7 and 8 show the difference in widths of spores derived from different patients. This difference is quite considerable, although the photographs are random ones with no attempt to select different sizes.

For three isolates, distinguished as A, B and C, the means and standard deviations of the widths are shown in the accompanying table:

	A	B	C
Mean.....	21.19 $\mu$	16.37 $\mu$	18.87 $\mu$
S.D.....	2.17 $\mu$	2.58 $\mu$	2.05 $\mu$

The difference between the means of A and B is 4.8  $\mu$ , the standard deviation of the difference is 3.4  $\mu$ , and therefore there is a probability of about 0.08 of obtaining as great a difference as this in samples of 100 by chance alone. The observed difference cannot therefore be regarded as significant, and we are not justified in assuming, as the photographs might suggest, that we are dealing with narrow-spored and wider-spored strains.

*Lengths.* Spore lengths, based on the measurements of one hundred spores did not vary much in most of the cultures. Figure 3 shows graphs of spore-lengths from three such cultures growing on Sabouraud's medium.<sup>4</sup>

However, when measurements were made from seven isolates,

<sup>3</sup> For the statistical computations of the spore measurements, the writers are indebted to Professor E. S. Keeping of the University of Alberta.

<sup>4</sup> It can be seen from figure 3 that most of the graphs have three peaks. These may possibly be due to personal errors in measurement. On the other hand each culture was obtained from a single infected hair but not from a single uninucleated spore, so that there are grounds for supposing that the original lesions were mixed infections of several strains with different spore lengths. This would produce a multi-modal graph characteristic of a mixed population.

it was found that while six resembled each other closely in spore length, one had much shorter spores. Comparison of the short-spored strain (D) with a representative long-spored culture (E) based on measurements of 100 spores each, is shown in the accompanying table.

	D	E
Mean.....	64.6 $\mu$	90.1 $\mu$
S.D.....	9.5 $\mu$	9.9 $\mu$

The probability that this difference in length is due purely to sampling fluctuations is only 0.03, so that we are probably justified in speaking of D and E as distinct strains.

Figure 4 shows that the maximum length of spores of the long-spored strain, is 120  $\mu$  (150  $\mu$  in Sabouraud's medium). Conant's maximum length of spores of *M. lanosum* is 94  $\mu$ . Dr. Conant has examined a number of the Canadian long-spored cultures and agrees that they are *Microsporum lanosum* although the spores are longer than any he has described. The same figure shows that the maximum length of spores of the short-spored strain is 85  $\mu$ .

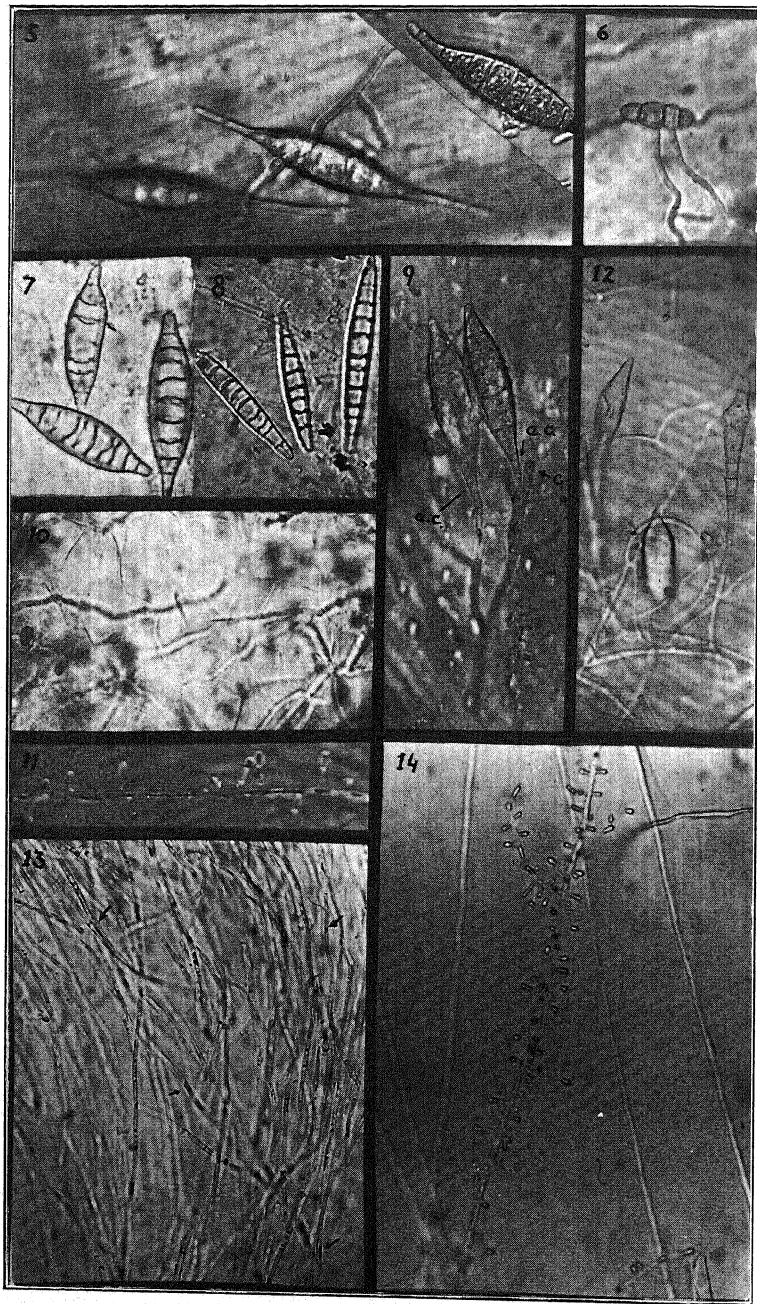
The spores from the two strains are illustrated in figure 19 and 20. The spores of the short-spored strain are less septate (this does not appear in figure 20), less torrulose, and are borne on rather stouter conidiophores than those of the long-spored strain. Dr. Emmons examined the short-spored strain and agrees that it is also *M. lanosum*.

No correlation could be discovered between the strain of *Microsporum lanosum* and the clinical type of ringworm which it caused, as is shown from the following observations:

(1) A long-spored strain and a short-spored strain were isolated from 2 different patients. Both of these patients possessed similar dry scaly lesions on the scalp.

(2) Cultures derived from dry scaly lesions of the scalp and cultures derived from inflammatory lesions showed no significant difference in spore length as is shown in the table.

The difference of the means for these cultures is so small compared with the standard deviations that the differences are clearly not significant.

FIGS. 5-14. *Microsporium lanosum*.

Type of Lesion	Scaly	Scaly	Inflammatory
Mean.....	106 $\mu$	110 $\mu$	102 $\mu$
S.D.....	13.7 $\mu$	11.3 $\mu$	11.9 $\mu$
Number.....	127	100	100

Figure 4 shows that the spore lengths of *Microsporum lanosum* may vary from 45 to 120  $\mu$ , a range of 75  $\mu$ . On this chart we have superimposed Conant's graph of spore lengths in *M. equinum* (4). It shows that there is actually more difference in spore lengths between the two strains of *M. lanosum* than there is between *M. lanosum* and *M. equinum*. *M. simiae* Conant is equally close to *M. lanosum* in spore length.

We have not had the opportunity of examining the species *M. equinum* or *M. simiae*, but if their validity depends principally on spore length we suggest they should be included in *M. lanosum*.

Conant separates *M. simiae* from other *Microspora* by an additional feature—the possession of an obconical cell of dehiscence at the base of the spore. Nevertheless such abscission cells occur in *M. lanosum* and in *M. fulvum* and will be described later in this paper.

#### 4. THE MICROCONIDIA

The microconidia of *Microsporum lanosum* are found in cultures a few days after inoculation, but they are most prolific on older mycelia. They are produced on aerial conidiophores, are sessile or with short necks, and measure  $3-5 \times 1-5 \mu$ .

The microconidium has been studied in detail in *Trichophyton gypsum* by Emmons (9). He observes that it arises from the conidiophore as a conical bud. He finds that the mature spore may itself bud to form a second spore, continuing in this way until a short chain of spores is formed.<sup>5</sup> He has observed that when the microconidium is shed it retains a collar of wall tissue which marks the place of attachment to the conidiophore, and that a scar marks the place on the conidiophore where the spore broke away.

<sup>5</sup> The writer has watched a similar formation of chains of spores by budding in *T. rubrum*.



The microconidia of *Microsporum lanosum* differ in a number of respects from those of *Trichophyton gypsum*: (1) The conidiophore is unbranched, so that the spores are not "en grappes"; (2) The spores are borne singly, not in chains; (3) The free microconidia have never been observed to possess collars, and no scars have been seen on the conidiophores.

In Van-Tieghem-cell cultures, the conidiophores and conidia that adhere to the cover-slip may be examined under high magnification without disturbing them. Many of the conidiophores are then found to be dissolved for all or part of their length, leaving the conidia free (FIG. 14).

The conidium is a more resistant structure than the conidiophore. The wall is thickened, particularly at the apex and base, and frequently possesses a longitudinal ridge of thickening (FIG. 11, 29). In iodine and sulphuric acid the conidiophore quickly disappears but the conidia persist.

Certain cells of the conidiophores may be found which are evidently of the same resistant material as the spores, for they persist like the spores and can be distinguished from them only by their barrel-like shape.

Mason (11), annotating the fungi received at the Imperial Mycological Institute, emphasizes that descriptions of spores should include their dispersal mechanism, *i.e.* whether they are "dry" spores adapted for distribution by air or "slime" spores adapted for distribution by water or another such agent.

The microconidia of *Microsporum lanosum* are produced most abundantly in wet cultures. They collect in the moisture exuded by the aerial mycelium and a smear of this liquid on a glass slide contains vast quantities of them. They are clearly "slime" spores.

"Slime" microconidia have been illustrated by the writer in *M. Audouini* (6), and Davidson and Gregory have illustrated them in *Achorion Schoenleinii* (7). On the other hand the microconidia of *Trichophyton gypsum* are normally "dry" spores, although under certain conditions, as we have illustrated (8), they are "slime" spores.

## 5. THE MACROCONIDIA

The mature macroconidium possesses at its base an empty cell which ruptures to set the spore free. It is illustrated in figures 9, 18 and 19. Different ages of macroconidia were studied to discover the way in which the cell is formed.

It was found that the macroconidium begins to form on 7-day-old cultures as a club-shaped swelling at the end of an aerial hypha. A septum then appears a little distance from the base of the swelling (FIG. 15). The outer wall now becomes irregularly tuberculate from the tip of the hypha to a short distance from the septum (FIG. 16, 17). About 24 hours later additional septa appear which are deposited on the outer wall and grow inwards, ceasing growth so that an annular perforation is left between adjacent cells (FIG. 18). At this time the outer wall thickens. The lowermost of the later-formed septa, together with the first formed septum, demark a cell with an average length of  $10\mu$ , with no tuberculate markings and no thickening on the wall. The contents of this cell are withdrawn into the two neighboring cells, and, being then empty, its two transverse septa bulge inwards. This cell is the abscission cell (FIG. 18). When the spore is shed the abscission cell ruptures in such a way as to leave usually a collar projecting from the base of the spore and also a collar surmounting the conidiophore (FIG. 21, 22).

Since the macroconidia are set free by the rupture of a special cell, and since they collect as a powdery deposit on the surface of the culture, they are clearly "dry" spores adapted for dispersal by air.

We have observed abscission cells at the base of the macroconidia of *Microsporum fulvum* and of *Trichophyton gypsum*. It is probable that the macroconidia of dermatophytes are regularly "dry" spores.

## 6. THE SECONDARY MYCELIUM

When rice cultures of *Microsporum lanosum* are about 20 days old, white tufts of mycelium appear sporadically over the surface. The tufts enlarge and meet one another until the whole sporulating surface is overlain by a white sheet-like covering. This transformation of a dermatophyte is usually known as "pleomorphism"

and the white growth as "pleomorphic" mycelium, but since (as will be shown later) this mycelium is not always completely pleomorphic in Sabouraud's sense, it will be described here as "secondary mycelium."

The secondary mycelium of *Microsporum lanosum* usually possesses the following characters:

(1) The hyphae are, on the whole, narrow, the average width being  $1.25\ \mu$ . (The width of the hyphae of the primary mycelium will range from  $7.5$  in extremely vigorous hyphae to  $1.9\ \mu$ , the average width being  $2.5\ \mu$ .)

(2) The culture may produce a few macroconidia, but most of these are not normal and do not produce septa or become thick-walled (FIG. 12). They frequently grow out from their apex or the base while still attached to the conidiophore. Often they are merely pear-shaped terminal swellings of the hyphae.

(3) Under moist conditions the culture will produce large numbers of microconidia (FIG. 14). Under dry conditions the culture is usually sterile.

(4) The inner surfaces of the cell walls of drier cultures possess characteristic thickenings sporadically distributed along the hypha. They take the form of thin plates or rings of irregular outline (FIG. 27, 28) which show clearly when the preparation is mounted in alcohol or lactic acid. Two microchemical tests for chitin were made upon the wall thickenings of secondary mycelia.

(a) Treated with iodine in potassium iodide and then with concentrated sulphuric acid, the unthickened portions of the wall are coloured blue and quickly dissolve. The thickened portions turn red and retain their shape for some time.

(b) When treated for a short time with fresh iodine in potassium iodide and then with concentrated chloride of zinc and washed in water, the unthickened portions are unaffected but the thickenings are coloured blue green.

Since the characteristic colour reaction for chitin in test (a) is brown, and in test (b) is violet, the thickenings must be some other form of cellulose.

(5) The secondary mycelium readily fragments into short lengths when it is mounted in water. This character is probably due to the uneven thickness of the cell walls.

Sabouraud has described dermatophytes as "pleomorphic" when they become overgrown by a white "duvet" of mycelium which produces no spores and which upon transfer to fresh medium (or even after passage through an experimental animal) remains sterile and will not revert to the original condition. Langeron and Milochevitch (10) also use this definition.

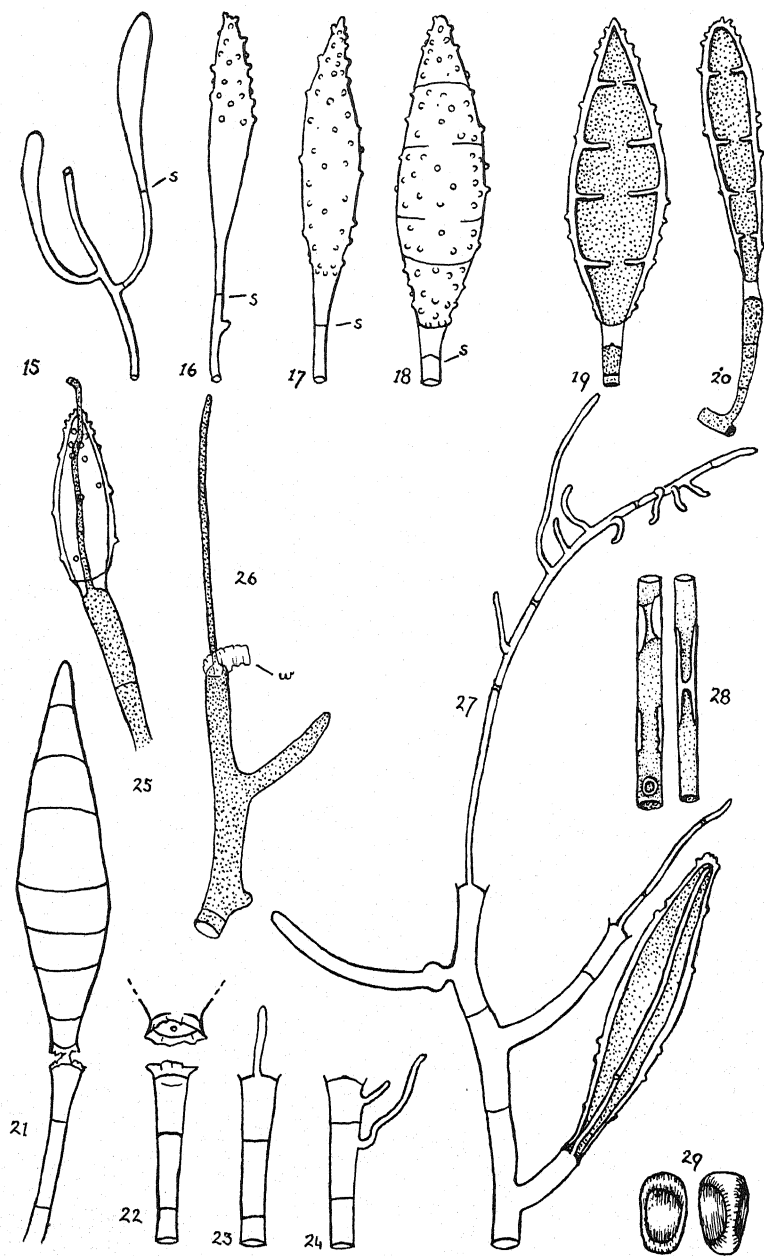
Transfers were made of the secondary mycelium of *Microsporium lanosum* to fresh medium to determine whether its condition was reversible or not.<sup>6</sup>

To make a transfer a small portion of the secondary mycelium was stripped from the surface of the culture and mounted in sterile water and examined microscopically to insure that there were no macroconidia carried over from beneath. The inoculum was then transferred to fresh rice. In this manner inoculations were made from secondary mycelia of cultures growing at room temperature for the following periods: 1 month; 2 months; 3 months; 5 months; 1 year. It was found that inocula three months old or less developed within two weeks into a cream-coloured mycelium with masses of macroconidia indistinguishable from cultures derived from the original infected hair or from a macroconidium. On the other hand transfers from inocula 5 months or a year old grew out into a white mycelium which usually produced microconidia but only occasionally macroconidia. In general they retain the characters of a secondary mycelium, but since they still produce spores, they could not be described as "pleomorphic" in Sabouraud's sense of the word.

An attempt was then made to determine in what manner the secondary mycelium originated from the primary mycelium.

Buller (1), working with *Pyronema confluens* and other fungi, found that after the experimental killing or natural death of a cell in a hypha, a plug immediately closes the pore of the septum of the living cell adjoining the dead cell and the septum bulges

<sup>6</sup> A two-months-old rice culture of *Microsporium lanosum* was sterilized in an autoclave. The underlying rice was then exposed by cutting away the mycelium, and inoculated with a portion of the secondary growth of a two-months-old culture. Within two weeks the inoculum had spread over the rice and become cream-coloured with masses of macroconidia, *i.e.*, the mycelium reverted to the primary condition. It was concluded that the secondary growth was not brought about by the staling of the medium.

FIGS. 15-29. *Microsporum lanosum*.

towards the dead cell. An intrahyphal hypha then grows out from the septum of the adjacent living cell into the dead cell.

In *Microsporium lanosum* when a cell of a hypha is wounded experimentally or when it dies naturally, a hypha grows out from the adjacent living cell as has been described by Buller. Since the new hypha does not necessarily grow within a dead cell it will here be termed a "secondary" rather than an "intrahyphal" hypha. A secondary hypha grows out, not from the whole septum but from the perforation, or from a small part of the wall, of the "primary" hypha, and it is always narrower than the primary hypha.

Figure 26 shows a hypha of *Microsporium lanosum* growing in a hanging drop of Sabouraud's medium in a Van Tieghem cell. It had been killed at the end by touching it with a hot needle and had died back to the septum which had become plugged. Twelve hours after wounding a secondary hypha has grown out from the septum and attained the length shown in the figure.

Figure 25 shows an aborted macroconidium from an old rice culture. The spore died and became empty without the formation of any septa except the basal septum of the abscission cell. A secondary hypha has grown out from this basal septum through the spore and out from its apex. Conant (5) illustrates a similar "germination" of the macroconidium.

The following observation suggests that the secondary mycelium of *Microsporium lanosum* takes its origin from secondary hyphae, usually growing out from the base of the abscission cell. Smallest possible masses of white secondary "duvet" from 20-day-old cultures, together with the underlying mycelium, were removed from the culture with a needle and examined microscopically. It was found that most of the spores had been shed. The bare conidiophores could be distinguished from other hyphae because they were wider at the tip (FIG. 9c), and frequently possessed a terminal collar left from the ruptured abscission cell. It was found that a great many of these conidiophores were growing out again. A narrow hypha pushed out through the plugged perforation of each bulging terminal septum (FIG. 23). Less frequently, hyphae grew out from other parts of the conidiophore (FIG. 24).

The secondary hyphae are narrow, measuring  $1.25\ \mu$ , frequently possess irregular thickenings (FIG. 27, 28), and have never been observed to produce spores.

Attempts were then made to induce the formation of the secondary mycelium experimentally.

(1) The aerial mycelium of two 6-day-old test-tube cultures which had not yet produced macroconidia was killed by drawing a hot L shaped platinum needle repeatedly over its surface. Within the next day or two, aerial hyphae had grown out again. Two weeks after wounding, the culture had produced no macroconidia, nor did it produce any during the next month. On the other hand, the two-weeks-old control culture which had not been wounded was covered with macroconidia.

(2) A six-day-old flask culture which had not yet produced macroconidia was wounded as described above. In the next two days the mycelium spread out over the untenanted rice at the periphery of the flask, and hyphae grew out again into the air from the wounded mycelium in the centre of the flask. After two weeks the mycelium at the periphery was in the primary condition. It was cream-coloured with a loose cottony texture and produced abundant macroconidia. The wounded central part of the culture had grown out into a white, densely downy mound of secondary mycelium which bore microconidia but no macroconidia. These two experiments show that the secondary mycelium, which naturally appears after the macroconidia are shed, may be produced experimentally before the macroconidia have formed, by wounding the primary mycelium.

#### SUMMARY

1. *Microsporum lanosum* may produce inflammatory or non-inflammatory lesions of the scalp. When it produces non-inflammatory lesions it may be clinically indistinguishable from *M. Audouini*. Since the *M. lanosum* and the *M. Audouini* ringworms yield differently to treatment, a mycological study of the dermatophyte is frequently of the utmost importance.

2. Two strains of *M. lanosum* have been isolated in Canada, one with short spores and one with long spores. The two strains produce the same clinical type of ringworm.

3. The microconidia and the macroconidia, both of which are produced upon artificial media, possess different dispersal mechanisms.

4. The microconidia are set free by the dissolution of the conidiophores and collect in slimy masses.

5. The macroconidia are set free by the rupture of certain cells termed abscission cells, and they collect as a powdery deposit over the surface of the culture.

6. The powdery spore deposit becomes overgrown by a close-textured white down, termed "secondary mycelium" which is composed of narrow, peculiarly thickened, almost sterile hyphae.

7. The secondary mycelium when it is still young may be transformed to the original primary condition by transfer to fresh medium but when it is older it remains in its secondary condition even after transfer.

8. The secondary mycelium usually originates from the base of the abscission cell after the spores are shed.

9. The secondary mycelium may be produced experimentally before the spores are produced, by wounding the primary mycelium.

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### EXPLANATION OF FIGURES

FIG. 1-4. *Microsporium lanosum*. Frequency graphs of lengths of macroconidia—each graph based on one hundred measurements.

FIG. 5-14. *Microsporium lanosum* (except Fig. 6). Magnification, 300 (except Fig. 11, which is 600). 5, macroconidia sown in a hanging-drop of corn-meal agar 24 hours ago, showing germ-tubes grown out from each end of the spores. 6, macroconidia of *M. fulvum* under similar conditions with germ-tubes growing from ends and side of spore. 7, macroconidia from culture derived from patient "F." 8, macroconidia from culture derived from patient "C." 9, macroconidia on 6-day-old rice culture; left, young spore without septa and with wall markings extending from the apex to the top of the abscission cell (*a.c.*) which is not yet cut off; centre, older spore with septa and with the abscission cell (*a.c.*) cut off; right, conidiophore (*c*) after the spore has been dispersed. 10, skin from lesion on hand, in potassium hydroxide to show mycelium. 12, abortive macroconidia on 28-day-old rice culture. 13, pleomorphic mycelium in lactic acid from culture left for one year at room temperature, to show irregular wall thickenings. (The arrows point to some of them.) 11 and 14, fugaceous hyphae bearing microconidia in 6-day-old Van-Tieghem-cell rice culture.

FIG. 15-29. *Microsporium lanosum*, magnification 400, except 28 and 29 which are larger. 15-18, stages in the development of the macroconidium. 15, formation of first septum, *s.* 16 and 17, development of wall thickenings. 18, appearance of other septa and delimitation of abscission cell. 19, macroconidium of long-spored strain. 20, of short-spored strain. 21 and 22, rupture of abscission cell and liberation of macroconidium. 23, 24 and 25, secondary growth from conidiophore (25, growth through dead spore). 26, secondary growth of hypha after wounding at *w* with hot needle. 27, secondary growth of three conidiophores. 28, types of wall-thickening in pleomorphic hyphae. 29, microconidia showing wall-thickening.

## PHOTOGRAPHS AND DESCRIPTIONS OF CUP-FUNGI—XXXI. MOLLISIELLA

FRED J. SEAVER

(WITH 1 FIGURE)

In January, 1938, the writer received from Miss Lenore Aldinger, of Madison, Wisconsin, a branch of avocado from Florida infected with *Tryblidiella*, on which occurred a minute discomycetous fungus, for study and determination. In April of the same year similar specimens were received from Dr. R. K. Voorhees, of Florida, under the name of *Cenangium Ravenelii* (Berk. & Curt.) Sacc. On checking up these two specimens it was found that *Cenangium Ravenelii* was regarded by Rehm as a synonym of *Mollisiella ilicincola* (Berk. & Br.) Masee. In the meantime the specimen sent from Wisconsin was determined by Mrs. Stiffer, of Chicago, as *Lachnellula hysterigena* (Berk. & Br.) Sacc. This was also regarded by Rehm as a synonym of *Mollisiella ilicincola*. Masee (Jour. Linn. Soc. 31: 522) also treated it as a synonym.

The name *Mollisiella* was first used by Phillips in his British Discomycetes as a subgenus of *Mollisia*. Later George Masee, in 1895, took up the name and used it for the globose spored species only. The genus was based on *Peziza ilicincola* Berk. & Br. Since the writer had not before encountered any American material of this genus, or species, he was especially glad to have the two collections from Florida. Since this genus and species is very unusual this opportunity is taken to describe and illustrate the fungus so that it may be recognized by later collectors. Following is the diagnoses of the genus and species:

**Mollisiella** (Phill.) Masee, British Fungus-Fl. 4: 221. 1895

*Mollisia* § *Mollisiella* Phill. British Discom. 193. 1893.

*Unguiculariopsis* Rehm, Ann. Myc. 7: 400. 1909.

Apothecia small cupulate becoming expanded, usually occurring on other fungi, externally dark-colored, brownish, tomentose or

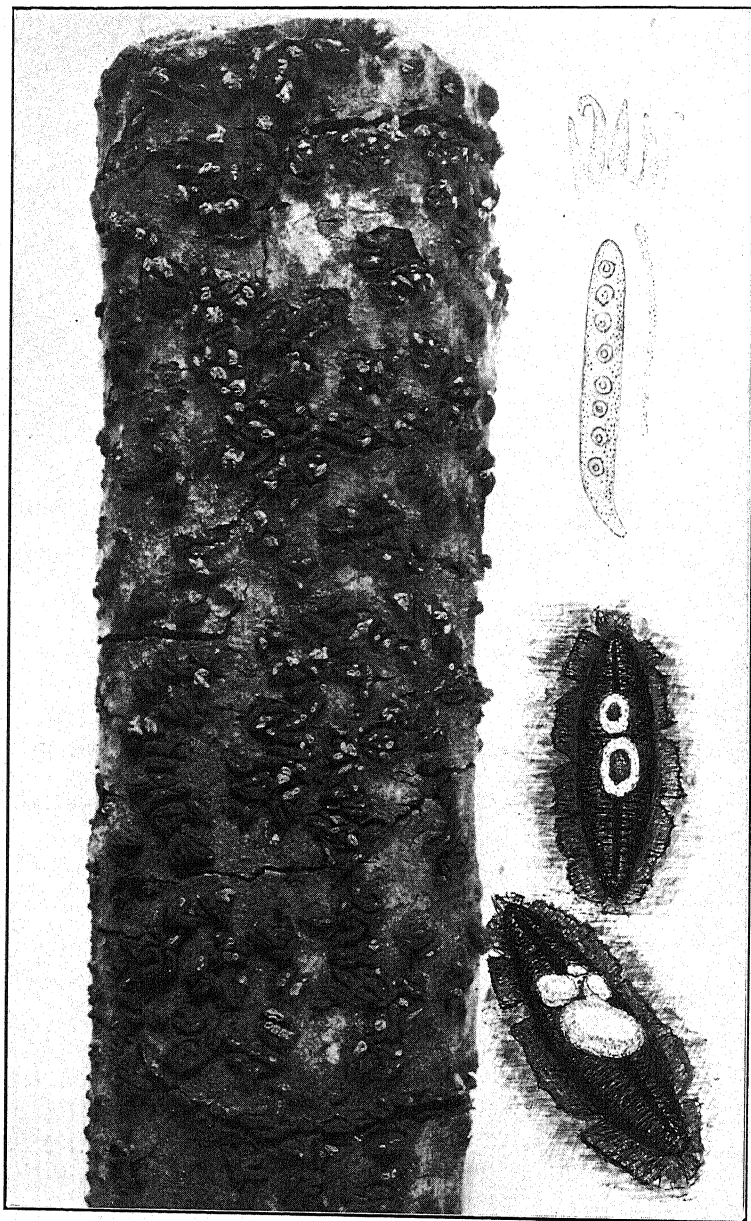


FIG. 1. *Mollisiella ilicincola*.

clothed with poorly developed hairs; asci clavate or cylindric, usually 8-spored; spores at maturity 1-seriate globose; paraphyses filiform, slightly enlarged above.

TYPE SPECIES, *Peziza ilicincola* Berk. & Br.

**Mollisiella ilicincola** (Berk. & Br.) Masee, British Fungus-Fl. 4: 222. 1895

*Peziza ilicincola* Berk. & Br. Ann. Mag. Nat. Hist. III. 7: 450. 1854.

*Peziza hysterigena* Berk. & Br. Jour. Linn. Soc. 14: 106. 1873.

*Peziza Ravenelii* Berk. & Curt.; Berk. Grevillea 3: 152. 1875.

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*Lachnellula hysterigena* Sacc. Syll. Fung. 8: 391. 1889.

*Cenangium Ravenelii* Sacc. Syll. Fung. 8: 568. 1889.

*Mollisia ilicincola* Phill. Brit. Discom. 193. 1893.

*Unguiculariopsis ilicincola* Rehm, Ann. Myc. 7: 400. 1909.

Apothecia occurring in fasciculate clusters 1–2 mm. in diameter the individual apothecia irregularly cupulate often compressed from mutual pressure with the margins strongly incurved, externally furfuraceous whitish or brownish, with poorly developed hairs; hymenium concave, pallid-brown or purplish to rosy; asci cylindric to clavate, 8-spored, reaching a length of 40–50  $\mu$  and a diameter of 5–6  $\mu$ , 8-spored; spores usually 1-seriate, 4–5  $\mu$  in diameter; paraphyses filiform, slightly enlarged above.

Usually on other fungi, *Myriangium*, *Patellaria*, *Hysterium* and *Tryblidiella*.

TYPE LOCALITY: Europe.

DISTRIBUTION: North Carolina to Florida; also in Europe.

ILLUSTRATIONS: Ann. Mag. Nat. Hist. III. 7: *pl. 16, f. 17*. Jour. Linn. Soc. 31: *pl. 18, f. 15–18*.

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#### EXPLANATION OF FIGURE

Left, photograph of a stick bearing apothecia of *Mollisiella ilicincola* on the hysterothecia of *Tryblidiella rufula*. Lower right, two hysterothecia much enlarged bearing apothecia. Above, drawing of an ascus with paraphysis and a clump of short hairs from the outside of the apothecium to the *Mollisiella*.

## THE ASCOCARP AND ASCOSPORE FORMATION IN STEVENSEA WRIGHTII

B. O. DODGE <sup>1</sup>

(WITH 2 FIGURES)

During the course of our studies on the diseases of the prickly pear, *Opuntia*, we obtained several new species of parasites. The diseases produced by some of these fungi have been described in previous publications (Dodge, 1937, a, b; 1938). The three principal diseases studied by Wolf (1912) had not at that time been encountered on specimens from Florida, New Mexico, and Bermuda. More recently we found that a very rapid rather soft rot disease sometimes developed on the segments of *O. amophila* that had just come in from Florida. Within a week after the first appearance of the spots the segments became well rotted and hundreds of pustules were found breaking through the surface of the segment and developing masses of beautifully crescent-shaped 1-septate spores. The disease symptoms, as well as the spore characteristics, agreed with those of *Gloeosporium lunatum* (*Mycosphaerella Opuntiae*). As Wolf made a thorough study of this species, it is unnecessary to add our observations except to note that the progress of the disease is comparatively rapid. No other disease of *Opuntia* that we have studied so quickly destroys the segment.

We had not seen at that time any specimens showing fruiting bodies of *Perisporium Wrightii*, the second disease studied by Wolf. On this new Florida material, however, we found at first a few spots (FIG. 2, F), where numbers of coal-black fruit bodies were developing in a circle. At this time the bodies were too young to show spores of any sort. Somewhat later not only on this particular segment, but on other segments, a large number

<sup>1</sup> The writer is indebted to Mr. Frank Paladino, for assistance in the preparation of material for study, and to Miss Bass Guttman, for the drawings (Fig. 1), both of the Works Progress Administration.

of spots from five to ten millimeters in diameter developed. Where these were close together they coalesced more or less (FIG. 2, E). Crushed mounts of some of the older fruiting bodies showed that they were ascocarps containing a few large roundish asci with septate spores. These asci developed irregularly in a pseudoparenchymatous matrix (FIG. 1, A-C). Sections made of fixed material gave much the same picture as that figured by Wolf, so that there seems to be no question that our fungus is closely related to the one he described as *Perisporium Wrightii*, especially as the young spores usually are of a beautiful pale-violet or lilac color, later turning light-brown. They differed somewhat from those figured by Wolf in that many of them developed longitudinal septa. We were uncertain at first as to whether these longitudinal marks were real septa until examination was made of stained preparations, where it was shown that they were, thus making the spores muriform (FIG. 1, D, E).

In compiling a list of the fungi which have been reported on species of *Opuntia*, a list which was further elaborated and which will no doubt be published by Miss Josephine McAllister in connection with her studies of one of the new species of fungi which were found on this material, it was noted that F. L. Stevens (1917) had reported a species of ascomycete under the name "*Perisporiopsis Wrightii* (B. & C.) comb. nov." Trotter (Sacc. Syll. Fung. 24: 261. 1926), finding later that the genus name *Perisporiopsis* F. L. Stevens was not available, created a new genus *Stevensea* with *S. Wrightii* (Berk. & Curt.) Sacc. as the type. Stevens says that the rare character of spores of violet color, turning to brown with age, seems to make it certain that the Porto Rican specimens and those studied by Wolf are co-specific. He pointed out, however, that the species could not be rightly regarded as belonging in the genus *Perisporium* because of the undoubted affinity with the Plectascineae, as shown by Wolf's drawings and his own specimens. He noted the additional character that the spores were frequently muriform.

It is interesting to find that W. C. Sturgis (Ellis collection Herbarium of The New York Botanical Garden) collecting at Grassman, Florida, in March 1893, found what he referred to as *Cookella?* on living stems of *Opuntia vulgaris*. His notes on

the packet are to the effect that the asci are "at first spherical, elliptical when mature, spores  $21.4-29.9 \times 10.7-12.8 \mu$ , hyaline." He has two clear-cut figures of spores showing longitudinal septa, one septum being diagonal. The fungus, according to a note on the packet added by Ellis, was identified by Ellis as "*Perisporium Wrightii* B. & C. No. 59, N. A. P. P. 56."

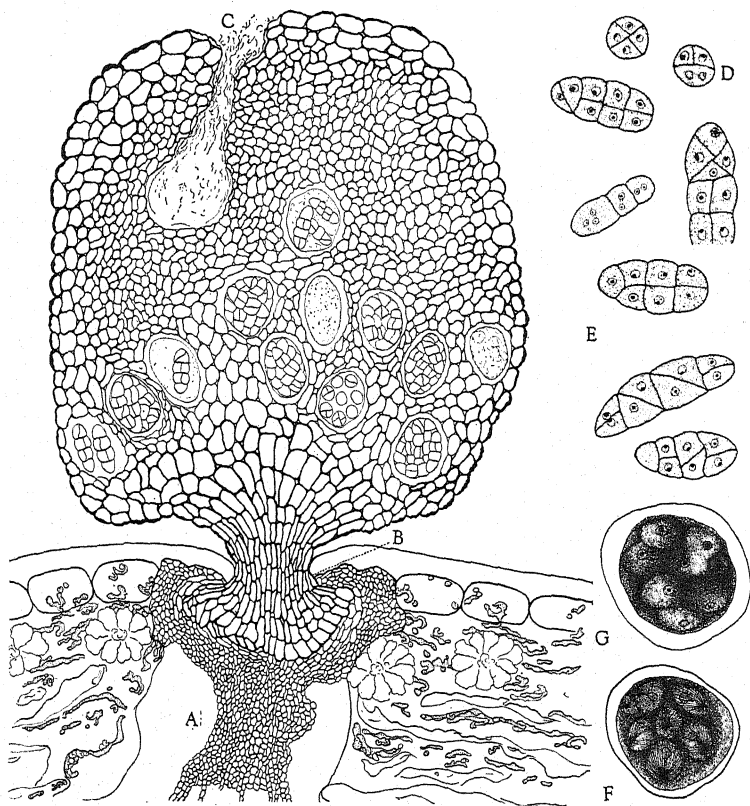


FIG. 1. *Stevensesa Wrightii*.

It is further to be noted that Ellis and Everhart (1892), in their description of *Perisporium Wrightii*, say that the spores show longitudinal septa, and also that the ostiola of the perithecia are papilliform and smooth, although in their characterization of the genus *Perisporium* the perithecia are said to open at length irregularly or with a circular mouth. There are certainly no or-

ganized ostiola in our material, otherwise we have been able to confirm the observations originally made by Ellis and also by Sturgis regarding the development of muriform spores. Our sections also show that the fungus cannot belong to the genus *Perisporium* because of the irregular distribution of the asci in a pseudoparenchymatous matrix such as characterizes the Myriangiaceae. This condition was accurately figured by Wolf and confirmed by Stevens, as noted. Even in old specimens the asci that develop are distinct, and not grouped together as though arising from some basal fertile area, an important point morphologically. Neither have we seen any asci that show definite stalks. At their origin they are more or less subglobose. Further elongation is due to the increase in length of the spores accompanied by a lessening of pressure from above due to disorganization of tissue to be noted later.

A few observations made in connection with these preparations may be of interest, although we are not putting them forward as a complete cytological account, merely noting that this material would certainly be excellent for studying the details of spore delimitation. We were unable to find any structure in the young ascocarps which could be looked upon as ascogonia. The fruiting bodies at first are made up of a mass of more or less undifferentiated pseudoparenchymatous tissue, the outer cells being somewhat more thick-walled (FIG. 2, *A*). As Wolf had noted, the structure develops at first in a substomatal cavity, then pushes up through to form the main part of the body superficially. One feature is the very characteristic foot-like structure just beneath the stomatal opening. This structure, expanded in the substomatal cavity, is embedded in a more delicately organized mass of tissue, the cells of which are much smaller and have thinner walls. The foot is connected to the perithecial body proper by a narrow isthmus of heavily carbonized tissue passing through the stomatal opening. Several upward growing layers of less heavily carbonized cells spread out fan-like from the stomatal opening to form the base of the ascocarp (FIG. 1, *A*, *B*).

The perithecium is globose, 180–250  $\mu$ . The foot structure is about 40–50  $\mu$  long and 34–40  $\mu$  wide as it enlarges in the substomatal cavity. At first the inner part of the perithecial struc-



ture is made up of homogeneous tissue and the one sees a few roundish asci developed rather above the center (FIG. 2, *A*). Older material (FIG. 2, *B*, *D*) shows a situation where many of the asci have matured their spores and discharged them through channels developed through the tissue above as the result of a disorganization of the cells. Most of our sections show a number of empty loculi above, with these irregularly progressing channels of disorganizing tissue leading to the surface. Below these loculi one always finds a number of asci with spores in various stages of development. Whether the development of asci is a continuous process or their development is seasonal, has not been determined. It looks, however, as though it were more or less progressive with interruptions due to unfavorable weather conditions. In the end the whole upper part of the fruit body will show the outer peridial wall cells broken away and the top of the cap irregularly bordered. When these fruit bodies dry out they close up at the top by a sort of infolding of the lacerated upper border.

One not infrequently sees very plainly the simultaneous delimitation of the eight spores in a stage in which the nuclei are very faintly stained, yet the central body at the beak and the astral rays extending outward and downward are very distinct, as shown more or less diagrammatically in our figure 1, *F*. Soon the nucleus in each spore rounds up and it now stains heavily so that it is more readily distinguished. The spores are at first subglobose (FIG. 1, *G*), soon becoming elongated, short elliptical, with a single nucleus at the center. As the spore elongates further this nucleus divides and, usually, the first cross-wall is then laid down. We have not followed closely nuclear division step by step, but we have found all stages showing that occasionally a cell will have four nuclei before the cross-walls are definitely visible. The longitudinal septa may be laid down in one side of the spore and yet not be found on the opposite side, as shown in cross section of spores (FIG. 1, *D*). In certain cases these longitudinal septa are more or less oblique, reaching from one corner to that diagonally opposite (FIG. 1, *E*). They do not thicken, however, as much as the three transverse septa, so that in crushed mounts the transverse septa are more striking, the longitudinal ones at first appearing as mere lines and might readily be mistaken for vacuole separations.

Many spores show only eight nuclei, but we believe that not infrequently there is further nuclear division, although not necessarily a simultaneous division of all of the nuclei of the spore. It is rather difficult in tracing serial sections to be sure that one is always looking at the same spore and not at a spore directly underneath. The longitudinal septa are certainly much more numerous than would appear from crushed mounts. We have never seen a spore that has reached any considerable stage of maturity that does not show more than four nuclei. At maturity each cell of the spore contains a single nucleus. Certain views of stained sections would seem to indicate that more than three cross-walls are possible, but here again we are uncertain. We have never seen more than three in crushed mounts. Very likely three is the characteristic number of transverse sections. Spores vary in size considerably, especially do they vary in their width. The wall of the ascus is usually rather thick, as shown in our figures. While most of the ascus contents are included in the spores, there is always a definite layer of epiplasm surrounding the mass of spores just being delimited. A study of progressive degeneration of the inner perithecial matrix should prove interesting and of phylogenetic importance.

A thorough cytological study of the mechanics of the development of muriform spores has never been made. Some years ago while studying *Pleosphaerulina intermixta* we observed that the longitudinal septations very frequently were laid down only through one half of the cell so that in a cross-section of a spore the one part would be quartered while the other would still be in the form of a semi-circle. It was further observed where both halves of the spore show longitudinal septations, these did not necessarily meet at the same point, showing that septations of the various segments of the spore are laid down independently.

Most of the cytological work on species included in the order of Perisporiales has been done on species of the Erysiphaceae. The enormous size of the primary nucleus of the ascus of *Stevensea* and the method of spore delimitation might suggest to some a relationship to the Erysiphaceae, yet the general organization of the fruiting body is quite different and the features just mentioned may be only accidental parallelism. We usually think

of the asci of species of *Perisporium* as being arranged more or less in a way suggesting a development from a basal fertile tissue. Wolf says of the asci: "They are at first irregularly scattered in the pseudoparenchyma. At maturity a hollow receptacle containing a group of asci is present." We did not attempt to culture this species, but we were satisfied that it is what Stevens placed in his new genus *Perisporiopsis*. Our species is probably the same as that studied by Wolf, as noted.

The asci of our material are usually somewhat spherical  $25-40\ \mu$  in diameter; some are rather elongated,  $35-40 \times 25-30\ \mu$  the ascospores are about  $20-30 \times 8-10\ \mu$ , agreeing very well with the measurements given by Sturgis and by Ellis & Everhart. Those asci measured by Wolf were "short obovate,  $20-26 \times 80-90\ \mu$  and the spores  $24-30 \times 10-14\ \mu$ ." Stevens could not find ascospores in Wolf's specimens loaned by The New York Botanical Garden, and he does not give the measurements of spores from his own material.

We were interested to find that the material in Wolf's original packet at The New York Botanical Garden does show many asci and that after twenty-six years the young asci and ascospores still show the beautiful lilac color first noted by the authors of the species. Some of the mature asci are a little larger than we find in our material. Otherwise the characters are the same.

As to the place of this fungus in a classification system one thing is certain, it is not a *Perisporium* as Stevens first pointed out, and, furthermore, it should not be included in the Perisporiales. The asci are developed irregularly in the perithecial stroma. They have no particular orientation unless one can say that if they are elongated at all they are usually elongated upward. The substomatal foot structure is like that of *Stomatogene* figured by Theissen (1916), but the asci do not arise in a cluster from a basal fertile tissue; neither are the asci long clavate.

*Cookella* (Saccardo 1882) in which genus Sturgis provisionally placed the fungus which he collected on *Opuntia* in Florida, may be closely related, but the perithecia of *Cookella* are applanate and the asci are said to be heaped together. The fruit bodies of our *Stevensia* are somewhat flattened when dry, but they are easily dislodged from the substratum showing the black spots

where the substomatal isthmus of tissue connecting with the foot structure has been broken off. Following the keys given us by Clements and Shear (1932) one always arrives at *Cookella* in the Myriangiaceae, although the ascocarps are not very membranous. Our sections (FIG. 2, B-D) certainly would suggest a discoid structure.

We have not seen specimens of *Cookella* but we have examined several collections of *Ascomycetella* Peck (1886), which Clements & Shear make a synonym of *Cookella*. There are certain similarities but *Ascomycetella* is not the same as *Stevensea* (*Perisporiopsis* Stevens) which Stevens says is unlike both *Meliola* and *Cleistotheca*. It is clearly one of the Myriangiaceae close to *Cookella* in the Clements & Shear keys.

The mechanics of spore delimitation found operating in *Stevensea* agrees with that described by Harper (1896) for the Erysiphaceae where the astral rays limit the sporeplasm to be included within the spore membrane. Several asci in our thick sections showed almost diagrammatically all eight spores being delimited.

In *Gelasinospora* (Dodge, 1937) we have a certain definite departure from this method. The beak of the nucleus with its central body is embedded in the sporeplasm, and astral rays proceed outward in all directions, but not necessarily in an infolding layer. The amount of sporeplasm included in a spore is determined by the extension of this ray system and not so much by its infolding. The paired spindles of the third nuclear division persist until the spores are fully delimited. The striking orientation of these spindles along the long axis of the ascus is a feature that must be considered in a description of the mechanics of spore formation in *Gelasinospora*. Vacuolization does enter in spore delimitation, at least along the lines separating the spores.

Jenkins (1934) has recently described the process of spore formation in *Cordyceps*. He believes that vacuolization plays a prominent part. In personal correspondence regarding this point Dr. Jenkins has elaborated his idea still further and I am permitted to quote from his letter, which certainly is a distinct further contribution on the subject.

"Your paper (on *Gelasinospora*) brings to mind a point that

I tried hard to make clear in my paper, but which I now see may be subject to serious misinterpretation.

"The whole question seems to involve the concept conveyed by the word 'delimitation' . . . ; but perhaps I should have distinguished in my paper between the phenomena of spore initial delineation and spore delimitation. This seems as essential to a clear understanding of spore formation as are the terms mitosis and cleavage to cell division.

"From your illustrations (*Gelasinospora*) and mine (*Cordyceps*) it is evident that the symmetry of the spore initial is distinct beyond any question before astral ray activity can be demonstrated. At this stage, I am reasonably certain that a membrane does not separate the periphery of the spore initial from the remainder of the ascoplasm. The above described process might well be described as spore delineation, and it apparently arises through the innate energizing influence of the nucleus or nuclei, as the case might be.

"This probable explanation arises from the fact that it is impossible to conceive of a nucleus as an entity separate from its complement of cytoplasm. This viewpoint harmonizes, also with a condition described first by Doctor Higgins and later by myself in which the paired nuclei of the ascogonium and ascogenous hyphae were embedded in masses of cytoplasm, denser than the remaining cytoplasm of the respective structures. Later, cleavage sets in and whether through the agency of astral rays or vacuoles, the spore is delimited from the standpoint that it becomes separate from the ascoplasm. My observations on the process in *Cordyceps* did not agree exactly with the published viewpoint of Doctor Harper, but in going over the matter again in the light of broader experience, it seems that we may have differed only in degree."

This is perhaps not the occasion to discuss in detail the mechanics of ascospore formation, especially, the statements recently appearing in literature on the cytology of the ascus where it is claimed that ascospores without nuclei can be delimited. The idea being that almost any agglomeration of cytoplasm, definite masses of fatty substances, or other organized material in any ascus, is an ascospore, whether it has a nucleus or not. Wilson (1936) agrees that the astral rays have something to do with spore de-

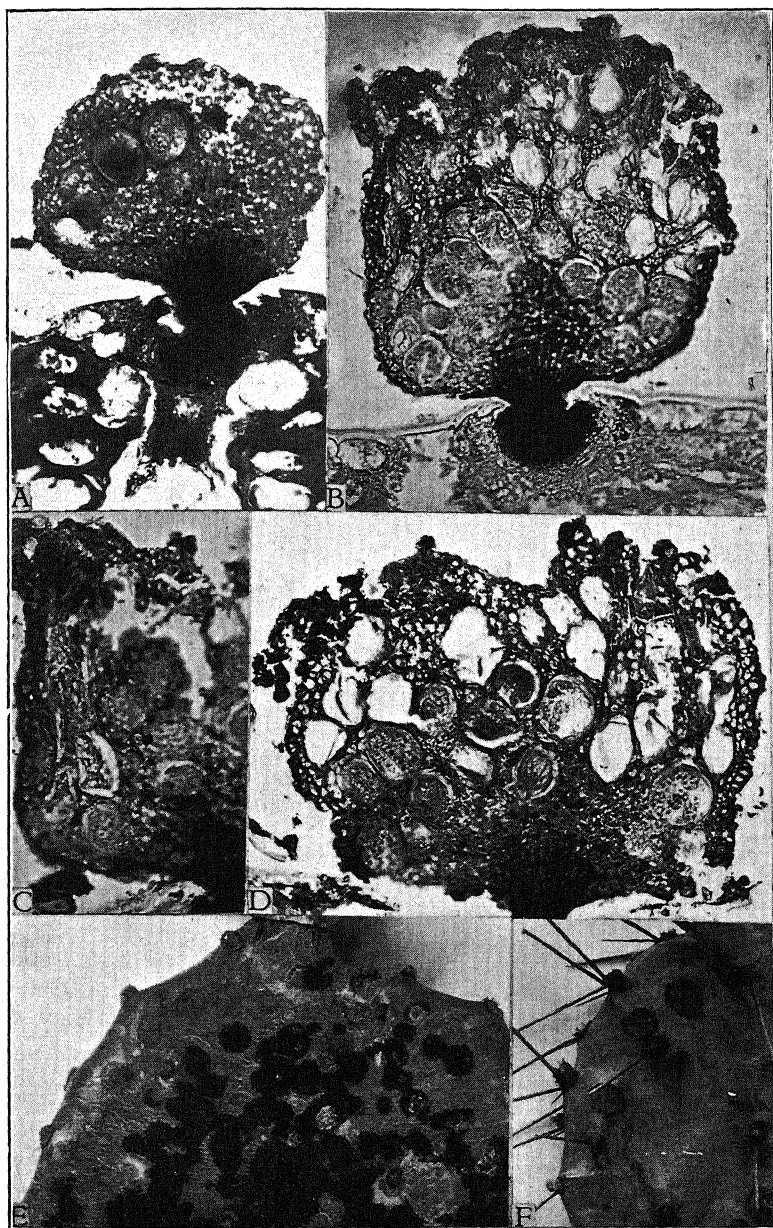


FIG. 2. *Stevensea Wrightii*.

limitation, but she also thinks she has akaryotic spores. She figures one ascus of *Peziza rutilans* with five spores, each of which has a nucleus. A sixth spore has three nuclei. This accounts for the eight nuclei. But there is, in addition, an "akaryotic" spore figured. Another ascus has eight normal spores, each with a nucleus. This same ascus has a ninth "spore" which lacks a nucleus. In *Neurospora tetrasperma* (Dodge 1936) when both parents in the mating carry the recessive lethal, *d*, the asci, being homozygous, *dd*, do not cut out any spores because the eight nuclei degenerate. There are usually present certain bodies which are filled with fatty substances as indicated by their reaction to osmic acid fixation. They are variously shaped. In bleached preparations, these bodies are proved to be vacuolar; they are not spores. Furthermore, many asci without spores result from the mating when one parent carries the dominant lethal, *I* (Dodge, 1934). But the ascus sac frequently persists and becomes indurated, brown and striated. Often such asci contain from one to fifty or more brownish, globose bodies. What they are is a question and one could insist that they are spores whether they have nuclei or not. There are some who think we have over-emphasized the importance of astral rays in ascospore formation, and overlooked the role of vacuoles in this operation. It is furthermore possible that the nucleus with its beak elongated and capped with a centrosome from which proceed, in some cases at least, astral rays, is not the essential mechanism at all for free-cell formation. In other words ascospore delimitation may be purely a function of the sporeplasm, the inclusion of a nucleus while incidental, would be very advantageous, of course, in providing for the next generation. This new idea should be further supported by positive evidence, however, before being accepted. Jenkins in his paper, and in the quotation from his letter included above, has raised some fundamental questions and has shown very clearly the need for a further intense study of the cytology of the ascus.

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## EXPLANATION OF FIGURES

FIG. 1. *Stevensea Wrightii*. Section of ascocarp, asci and spores. *A*. Sub-stomatal cavity containing mass of tissue with thin-walled cells in which is embedded the foot, *B*, which is composed of brown thick-walled cells. Vegetative hyphae in the intercellular substance sending haustorium-like contorted branches into the cell chambers. The main body of the ascocarp above is bordered by a peridial layer of cells whose outer walls are heavily carbonized. The inner part of the structure, except for the basal portion consisting of expanding upward-growing cell tiers, is composed of a pseudo-parenchymatous mass of thin-walled cells. There are no indications of ascogenous hyphae from which the asci proceed. Several loculi with subglobose asci with spores are indicated. At *C* the opening in the stomatic



tissue developed through disorganization has allowed for the discharge of the matured spores from the loculus below. *D.* Cross sections of ascospores showing the manner in which longitudinal septa may be placed. *E.* Sections of other spores showing diagonal orientations of septa as well as some that are strictly longitudinal. Each spore has at maturity three cross-walls and each cell has one nucleus. One spore below shows a cell without a nucleus. This would have been present in the next section. *F.* Ascus showing seven spores being delimited. A beaked nucleus attached to the centrosome can be seen in each spore. Astral rays show very diagrammatically in the preparation. *G.* Ascus showing eight young elliptical spores fully delimited. Each spore has a single nucleus.

FIG. 2. *Stevensia Wrightii*. *A.* Section through young ascocarp the foot-like base of which is seen in the substomatal cavity; three young subglobose asci reaching maturity. The outer peridial wall of the ascocarp still intact. *B.* Old ascocarp showing the heavily carbonized foot structure and the upward growing rows of basal cells composing the sterile tissue serving as a stalk. A number of asci in various stages of maturity show in the lower part of the fruit body while above can be seen loculi with canals leading to the periphery and through which the mature ascospores have been discharged. The outer wall of the peridium above is much lacerated. *C.* At the left canals of disorganization extending from loculi from which the spores have just been discharged. The loculi still contain disorganized epiplasm. *D.* Two very distinct discharge canals leading from loculi below. Longitudinal septa can be seen in most of the ascospores in some of the other loculi. *E.* Portion of segment of *Opuntia amophila* showing black spots composed of many ascocarps. At the left some spots show where the ascocarps will appear later. *F.* Three infection spots each showing a ring of young perithecia.

## NOTES AND BRIEF ARTICLES

### FLORA ITALICA CRYPTOGRAMA

Fascicle 17 of Flora Italica Cryptogama, published by the Societa Botanica Italiana, has recently appeared. This fascicle is a continuation of the studies of the fungi of Italy, and comprises a volume of 440 pages devoted to a monograph of the Ustilaginales, including the Tilletiaceae, Graphiolaceae, and Ustilaginaceae, by Raphael Ciferri. The work is sparingly illustrated. The author is to be congratulated on his extensive contribution to our knowledge of the fungi of Italy.—F. J. SEAVER.

### A CASE OF POISONING BY *LEPIOTA MORGANI*

On August 27th a resident \* of East Lansing, Michigan, purchased a mess of mushrooms at the Lansing City Market. The vendor, from whom she had purchased mushrooms before for several years, assured her that they were safe, being "shaggy-manes." Being suspicious because of the greenish color of the gills the lady saved some specimens uncooked. Only she and her father-in-law partook of the cooked mushrooms, each eating not over a tablespoonful. Within two hours both were violently sick with intense vomiting and bowel movements, the stools being bloody. The victims became very pale but soon the skin took on a greenish-yellow color. Both experienced a feeling of extreme weakness which persisted several days. The attending physician gave hypodermic stimulants and did not consider the lady out of danger for 12 hours or her father-in-law for 24 hours after the onset of the symptoms. The uncooked specimens were submitted to the Department of Botany of Michigan State College and were beyond shadow of doubt *Lepiota Morgani* Peck, which is abundant in this vicinity nearly every Fall. The vendor when shown pictures (without English names) of several mushrooms including the true shaggy-mane (*Coprinus comatus*) at once selected the pic-

\* Name on file in the author's records.

ture of *Lepiota Morgani* as being the mushroom she called "shaggy-mane."—ERNST A. BESSEY.

#### POISONING WITH CLITOCYBE ILLUDENS

Recently a practicing physician called at the writer's home with a paper bag full of a bright-yellow mushroom, stating that his patient had eaten of this mushroom and was very ill. He naturally wished to know the identity and nature of the suspected offender. It was readily identified as *Clitocybe illudens*, or the Jack-o-lantern fungus, well known to mycologists because of its attractive appearance and phosphorescent habits. The physician was informed that while this mushroom was usually listed as poisonous it was not one of the deadly forms, and his patient would not die.

A later report from this physician was as follows: "About one whole mushroom was eaten by the patient and immediately after ingestion of same, she felt a heavy sensation in the stomach, whereupon she induced vomiting by the usual household methods ridding herself after four or five attempts of all the mushroom she had eaten. At the time I saw her, patient was up and about but still nauseous and somewhat exhausted, most likely from the strain of vomiting, but pulse and respirations were quite normal. The vomitus at the time of my examination was clear. Throughout the day she felt somewhat tired and sleepy, but the following day felt perfectly well and has been well since."—FRED J. SEAVER.

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#### THREE NEW BOLETES

Specimens here cited are to be found in the Herbarium of the Florida Agricultural Experiment Station, at Gainesville.

##### *Ceriumyces flavimarginatus* sp. nov.

Pileo convexo, 8 cm. lato, rubro-fulvo; tubulis flavo-virescentibus, sporis fusiformibus, flavo-brunneis,  $14 \times 4-5 \mu$ ; stipite flavo, reticulato,  $3 \times 0.8-1.5$  cm.

Pileus convex, scattered, about 8 cm. broad; surface slightly viscid when moist, minutely tomentose, uniformly reddish-fulvous, margin even, entire, sterile, yellow below; context rather thin, of

mild flavor, white, unchanging, purplish under the cuticle; tubes reaching 1 cm. or more in length, depressed about the stipe, bright yellow with a greenish tint, mouths large, 1-2 to a mm., angular, the young marginal tubes remaining yellow and forming a distinct band; spores fusiform or boat-shaped, smooth, pale yellowish-brown, about  $14 \times 4-5 \mu$ ; stipe tapering upward, glabrous, pale yellow and delicately reticulate above, ferruginous at the very base,  $3-5 \times 1-2$  cm.

Type collected by W. A. Murrill under an evergreen oak at Gainesville, Fla., June 14, 1938 (No. *F 16467*). After drying the cap has changed little in color, while the yellow stipe and marginal band show up in vivid contrast to the dark yellowish-green hymenium.

***Ceratomyces subsensibilis* sp. nov.**

Pileo convexo, gregario, 7-10 cm. lato, ferrugineo-flavo ad livido-umbrino; sporis  $14 \times 4 \mu$ ; stipite flavo, reticulato,  $4-6 \times 1.5-2$  cm.

Pileus broadly convex, gregarious, 7-10 cm. broad; surface smooth, minutely floccose-tomentose, uniformly ferruginous-flavous to livid-umbrinous, margin regular or somewhat lobed; context firm, whitish or creameous, becoming pale-blue when wounded, sweet and nutty, 1-1.5 cm. thick; tubes decurrent, yellow to mel-leous or darker, becoming bluish-green when wounded, about 1 cm. long, mouths irregular, angular, entire, 1-2 to a mm.; spores elongate, fusiform, smooth, yellowish-brown, about  $14 \times 4 \mu$ ; stipe tapering downward,  $4-6 \times 1.5-2$  cm., flavous above, reddish-brown below, blue where touched, coarsely reticulate, creameous within, purplish at the base.

Type collected by W. A. Murrill on a lawn under a laurel oak in Gainesville, Fla., June 8, 1938 (No. *F 16374*). Also collected by the author under oaks in Gainesville, June 5 and 13, 1938 (*F 16483*, *F 16451*). The yellow part of the stem is sensitive to the touch but not the cap. The coarse reticulations over the stem are delicately traced but distinct.

***Gyroporus pisciodorus* sp. nov.**

Pileo convexo, 8-12 cm. lato, tomentuloso, ochraceo-fulvo ad subumbrino, sapore grato; sporis hyalinis,  $12 \times 3-4 \mu$ , stipite reticulato,  $6-8 \times 2-3.5 \mu$ .

Pileus convex, thick, gregarious or cespitose, 8-12 cm. broad; surface dry, smooth, finely tomentose, ochraceous-fulvous to sub-

umbrinous, margin entire, even; context thick, white, unchanging, sweet and nutty, with a decided fishy odor; tubes depressed, long, white to fulvous, mouths at first covered with a floccose membrane, subcircular, entire, 1-2 to a mm.; spores elongate, smooth, multinucleate, perfectly hyaline in mass, about  $12 \times 3-4 \mu$ ; stipe thick, subequal or tapering downward, pallid and strongly reticulate above, furfuraceous and pale umbrinous below, solid, white above within and grayish below,  $6-8 \times 2-3.5$  cm.

Type collected by W. A. Murrill near a live-oak and a pine at the Tung-oil Mill on the Newberry Road west of Gainesville, Fla., June 18, 1938 (No. *F 16258*). Having the appearance of *Tylopilus indecicus* (Peck) Murr., but with a pronounced fishy odor and absolutely hyaline spores. This characteristic odor develops more strongly in the process of drying; and, while bending over the electric oven, I could easily imagine myself tending a mess of big-mouthed bass.

#### NEW COMBINATIONS

For those using the older nomenclature the following new combinations are made:

CERIOMYCES FLAVIMARGINATUS = *Boletus flavimarginatus*

CERIOMYCES SUBSENSIBILIS = *Boletus subsensibilis*

GYROPORUS PISCIDORUS = *Boletus pisciodorus*

W. A. MURRILL.

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## THE VALIDITY AND MORPHOLOGY OF TWO TRYBLIDIELLA SPECIES

R. K. VOORHEES

(WITH 4 FIGURES)

The lack of agreement in the literature on the taxonomic treatment of the genus *Tryblidiella* is perhaps due largely to our still meager knowledge of the natural relationships in this group of fungi. In his description of the genus *Tryblidiella*, Saccardo (7), included a group of Discomycetes having brown ascospores with two or more septa, and designated *T. rufula* (Spreng.) Sacc. as the type species. In 1892, Ellis & Everhart (4), reduced the genus *Tryblidiella* to a sub-genus of *Tryblidium*. Later, 1904, Rehm (6), included the one-septate brown spored species under *Tryblidiella*, sub-genus *Eutryblidiella*, and the three- to five-septate brown spored species under *Tryblidiella*, sub-genus *Rhydithysterium*. After reviewing the literature on the genus *Tryblidiella*, it is the opinion of the writer that those forms having brown three-septate ascospores belong in this genus as originally described by Saccardo.

Of this group, *Tryblidiella rufula* (Spreng.) Sacc., and *Tryblidiella fusca* (Ellis & Ev.) Rehm were the forms studied. *T. rufula*, a somewhat variable species, was described by Saccardo (7), in 1883. Later, 1889, material collected by Calkins near Jacksonville, Florida, was described by Ellis & Everhart (3), as *Tryblidium rufulum* Spreng. var. *fuscum* Ellis & Ev., because it

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FIG. 1. (A), open and closed apothecia of *Trybliidiella rufula* on *Pistacia chinensis*, No. 12166; (B), open and closed apothecia of *T. fusca* on *Pistacia chinensis*, No. 12167. All  $\times 2$ ; (C and D), open and closed apothecia of *T. rufula* on *Pistacia chinensis*, No. 12166; (E and F), open and closed apothecia of *T. fusca* on *Pistacia chinensis*, No. 12167. All  $\times 7$ . (G), apothecia of *T. fusca* on dying limb of *Pyrus chinensis*, natural size.

had a slate-colored hymenium and the lips of the apothecia very distinctly striate. In 1892, they (4) gave this fungus the specific rank of *T. fuscum* Ellis & Ev., on account of the clustered apothecia, slate-colored hymenium and the clavate-tipped paraphyses. In 1900, Rhem (5) changed the binomial to *Tryblidiella fusca* (Ellis & Ev.) Rehm. Later, 1904, he (6) reduced it to a variety of *T. rufula* (Spreng.) Sacc. As a result of the present studies, both *T. rufula* and *T. fusca* are considered entitled to specific rank. This conclusion is based on differences in some of their outstanding morphological characters in nature and in culture, as described below.

Although the apothecia of both species are commonly found together on the same specimen, they may be easily separated on the basis of certain macroscopic characters. The lips of the apothecia may or may not be transversely striate in *T. rufula*, but when present these striae are rather indistinct as compared with the very distinct striae of *T. fusca* (FIG. 1, C, D, E, F). Also, the brick-red hymenium of the brownish-black apothecia of the former is quite distinct from the slate-colored hymenium of the black apothecia of the latter. The brick-red hymenium of *T. rufula* is usually indistinct until the apothecia have been opened by moisture. When dry the sides of the apothecia of both species roll in so as to partly or almost completely cover the hymenium, and the measurements of both forms fall within the limits of  $1-3.5 \times .5-1$  mm., but when moist the width of the apothecia of *T. fusca* may exceed that of *T. rufula* by .5 mm. The apothecia of *T. fusca* may be slightly more stipitate than those of *T. rufula*, and the lips of the former are slightly thicker than those of the latter. In other respects the apothecia of these two species are quite similar in that they may be scattered or cespitose, erumpent-superficial, sub-orbicular, elliptical, triangular or otherwise irregular from crowding (FIG. 1).

The two species are inseparable on the basis of known microscopic characters. Their asci are cylindrical, with abundant clavate-tipped paraphyses. The ascospores are uniseriate, oblong, three-septate, constricted at the septa, and reddish-brown in color (FIG. 4). In the present study 100 ascospores of *T. rufula*, from



*Pistacia chinensis*, No. 12166,<sup>1</sup> and *Pyrus chinensis*, No. 12168, measured  $27-36 \times 10-14 \mu$ , averaging  $31 \times 11 \mu$ , as compared with  $30-35 \times 10 \mu$ , as given by Saccardo (7), and  $24-30 \times 10-12 \mu$  as given by Ellis and Everhart (4). Also, 100 ascospores of *T. fusca*, from *Pistacia chinensis*, No. 12167, and *Pyrus chinensis*, No. 12169 measured  $27-37 \times 10-14 \mu$ , averaging  $31 \times 11 \mu$ , as compared with  $25-30 \times 10-14 \mu$ , as given by Ellis and Everhart (4).

Several single ascospore cultures of both species from various hosts were grown on cornmeal agar and potato-dextrose agar in test tubes and petri dishes. At first the mycelial growth from ascospores of both species was dirty-white in appearance, the mycelium of the *T. rufula* becoming light reddish-brown to mouse-gray, while that of *T. fusca* became deep reddish-brown to blackish-brown. In all cases the mycelium of *T. fusca* was darker than that of *T. rufula*.

Later several single ascospore cultures of both species were planted singly and in various combinations on cornmeal in flasks. After a period of approximately thirty days a few small dull white gelatinous masses were observed scattered over the surface of some of these cultures (FIG. 2 B). Microscopic examination showed these masses to consist of numerous hyaline subglobose microspores  $2-3 \mu$  in diameter (FIG. 3 E), similar to those described by Shear (10). Further examination showed these small spores to be exuded from numerous locules, irregular in size and shape, resembling micropycnidia and embedded in a somewhat discontinuous stroma (FIG. 2, C, D). The microspores are borne on short conidiophores lining the inner surface of these locules. Microspores from ascospore cultures of both *T. rufula* and *T. fusca* were transferred to potato-dextrose agar in petri dishes. After a reasonable period of time they showed no signs of germination, thus they were considered to be made cells of the fungus, perhaps similar to the spermatia of certain other discomycetes, Laboulbeniales, and the rusts. The manner in which the microspores of these two *Tryblidiella* species are borne would compare more closely to the spermatogonia of certain forms in the genus *Pycnopeziza*

<sup>1</sup> Numbers refer to specimens in the Florida Agricultural Experiment Station Herbarium.

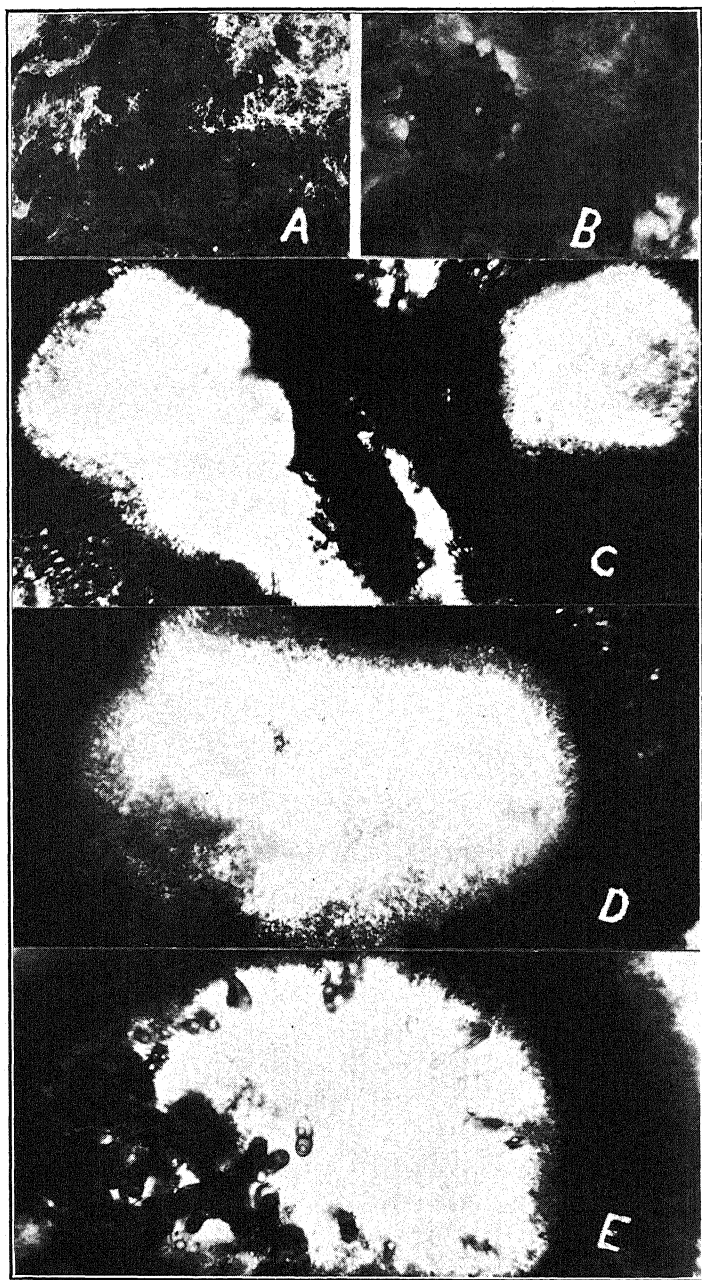


FIG. 2. (A), mature apothecia of *Tryblidiella fusca* from single ascospore culture on cornmeal,  $\times 7$ ; (B), microspores exuding from micropycnidia of *T. fusca* from single ascospore culture on cornmeal,  $\times 7$ . Freehand sections of pycnidia from single ascospore cultures on cornmeal; (C), micropycnidia of *T. rufula*; (D), micropycnidium of *T. fusca*; (E), macropycnidia of *T. fusca*. All  $\times 200$ .

(11), than to similar structures of other discomycetes and ascomycetes where they are borne on conidiophores arising directly from the mycelium. Due to the lack of cytological evidence in these studies, nothing definite can be concluded concerning the function of these microspores at present. However, since mature apothecia developed in some of the single ascospore cultures of both species (FIG. 2 A), as well as in some of the flasks containing two ascospore cultures, it seems reasonable to assume that if these microspores are male sex organs, spermatization between compatible isolates is not necessary for the production of mature apothecia. In other words, single ascospore cultures of these two *Tryblidiella* species seem to be structurally hermaphroditic and self-fertile, as compared to single uninucleate ascospore cultures of such forms as *Sclerotinia Gladioli* (Massey) Drayton (2), and *Pleurage anserina* (Ces.) Kuntze (1), which are also structurally hermaphroditic but self-sterile. According to Shear (10) mature apothecia were also produced in a single ascospore culture of *T. Leprieuri* (Mont.) Sacc.

In most of the cornmeal cultures of *T. rufula* and *T. fusca* *Diplodia*-like pycnidia were also found embedded and associated with the micropycnidia in the same stroma (FIG. 2 E). Both pycnidia types were also produced in some of the test tube cultures. Spores from these *Diplodia*-like pycnidia of both species were one-septate, yellowish-brown, falling within the limits of  $15-28 \times 7-12 \mu$ , the pycnosporos of *T. rufula* averaged  $23.3 \times 9.6 \mu$ , while those of *T. fusca* averaged  $22.2 \times 8.4 \mu$  (FIG. 3, B, C). According to Shear (10) two of his collections on different hosts which agreed with the description of *T. rufula*, and which could not be separated on the basis of the morphology of their apothecia and ascospores, produced distinctly different pycnosporos in culture, one type being broadly striate and resembling *D. natalensis*, in everything but size, the other type resembling pycnosporos of *D. Mori*. Thus, he is doubtful which, if either, is true *T. rufula*. In the present studies none of the *Diplodia*-like spores from ascospore cultures of either *T. rufula* or *T. fusca* showed any striations similar to those of *D. natalensis*. Therefore, the absence of these markings on the spore wall, as well as the color, size and shape of these spores would distinguish them from the

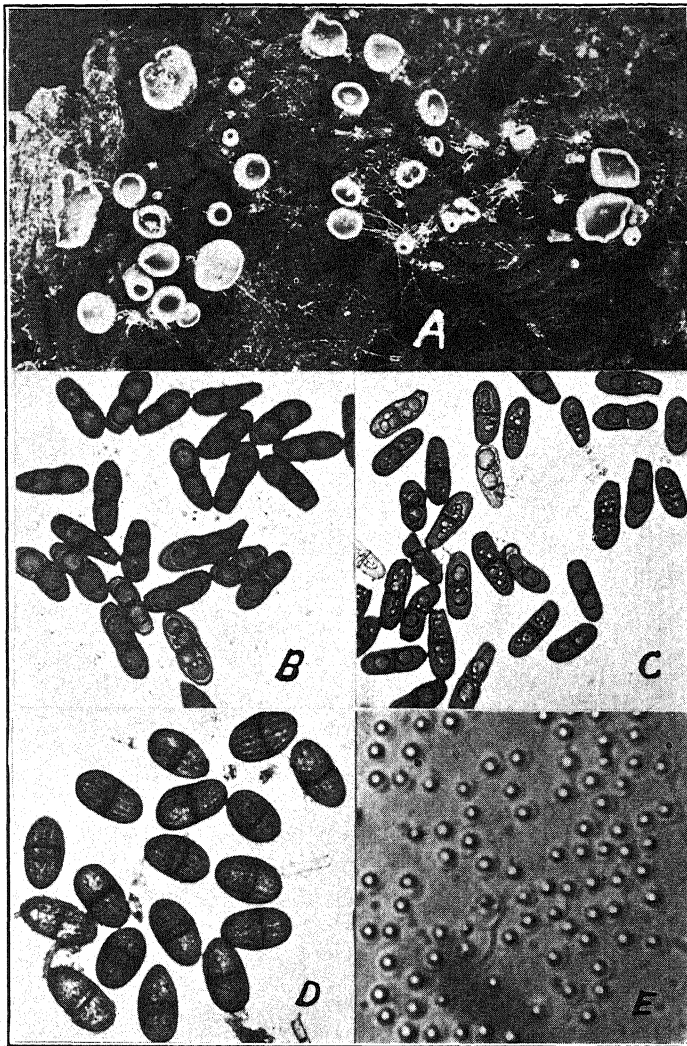


FIG. 3. (A), apothecia of *Cenangium Ravenelii* growing on apothecia of *Tryblidiella rufula* on *Pistacia chinensis*, No. 12170,  $\times 7$ ; (B), pycnospores from single ascospore culture of *T. rufula* on cornmeal; (C), pycnospores from single ascospore culture of *T. fusca* on cornmeal; (D), pycnospores of *D. natalensis* from single pycnospore culture on cornmeal. All  $\times 400$ ; (E), microspores of *T. rufula* from single ascospore culture on cornmeal,  $\times 1000$ .

typical spores of *D. natalensis*. The ratio of length to width of the pycnospores of *T. rufula* and *T. fusca* is greater than that in pycnospores of *D. natalensis*. The pycnospores of these two *Tryblidiella* species in culture are also more irregular in size and shape and more constricted at the septa than those of *D. natalensis* (FIG. 3 B, C, D). Also the few pycnidia found associated with, but probably not connected with, the *Tryblidiella* apothecia in nature do not produce spores comparing with those found in the present culture studies, but are of the *D. natalensis* type. The mycelial growth of several single pycnospore cultures of both *Tryblidiella* species could not be differentiated from that of the ascospore cultures. The mycelial growth of both *T. rufula* and *T. fusca* is very slow and the rate and color of the mycelial growth of both species in culture is quite distinct from that of *D. natalensis*.

Since these forms are, for the most part, considered to be saprophytic in nature, occurring on dead limbs of various trees, no attempt has been made in the present study to complete a list of the hosts on which they have been reported. In a few collection these two forms appeared to function as wound parasites, but there is no experimental evidence confirming their possible parasitism. As shown in figure 1 G, a pear limb is apparently being killed by *T. fusca*, which probably entered through a wound on a side branch. Collections of these two forms on various hosts have been deposited in the following herbaria: Florida Agricultural Experiment Station; New York Botanical Garden; Bureau of Plant Industry, Washington, D. C.

#### CENANGIUM RAVENELII ON TRYBLIDIELLA APOTHECIA

A Discomycete having small, cup-shaped, reddish-brown apothecia, and known as *Cenangium Ravenelii* (Berk. & Curt.) Sacc. (8), was found growing on apothecia of *T. rufula* and *T. fusca*. It was found on the apothecia of *T. rufula* in several collections (FIG. 3 A), but was found in only one collection of *T. fusca*. A few apothecia of this fungus appeared to be growing directly on the host bark. However, due to the lack of experimental evidence nothing definite can be concluded concerning its possible parasitism on *Tryblidiella* apothecia.

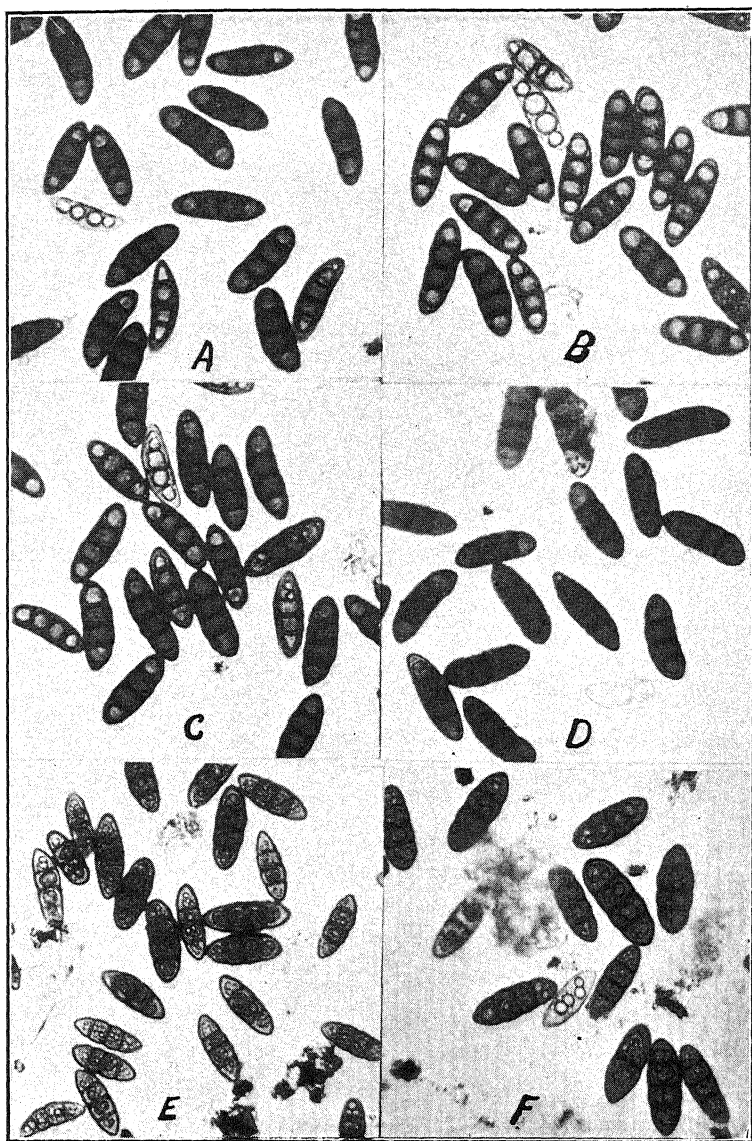


FIG. 4. (A), ascospores of *Tryblidiella fusca* from *Pistacia chinensis*, No. 12167; (B), ascospores of *T. fusca* from *Pyrus chinensis*, No. 12166; (D), ascospores of *T. rufula* from *Pyrus chinensis*, No. 12168; (E), ascospores from single ascospore culture of *T. fusca* from *Pistacia chinensis*, No. 12167; (F), ascospores from single ascospore culture of *T. rufula* from *Pistacia chinensis*, No. 12166. All  $\times 400$ .

This fungus has been reported from North America on *T. rufula*, and *T. nigrocinnabarina* (9). However, as far as known this is the first report of it on *T. fusca*, and also the first report of it on *T. rufula* and *T. fusca* from Florida.

#### DISCUSSION

The genetic connection of the different types of fruiting bodies here described as occurring in the life cycles of *T. rufula* and *T. fusca*, cannot be ascertained at present. Collections of these two forms made throughout the year have failed to reveal the presence of any pycnidial and spermogonial structures similar to those produced in pure culture. However, the presence of these structures may not be necessary for the reproduction of these forms in nature, since mature apothecia of both species were produced in single ascospore cultures.

According to our present ideas of classification, these two forms can be separated into distinct species by the morphological characters of the ascocarps. The conidial forms of *T. rufula* and *T. fusca* must be regarded as having little or no specific significance, at least for the present. The genus *Tryblidiella* has been insufficiently studied and, therefore, any scheme of natural classification applied to it must be regarded as tentative. Although the general character and appearance of the *Tryblidiella* pycniospores are similar to those in the genus *Diplodia*, yet, as Shear (10) has suggested, it seems rather remarkable that the pycnidial forms of such widely separated genera as *Tryblidiella* and *Physalospora* should be referred to the same form genus, *Diplodia*. A more thorough study of the characters of these pycnidial forms, however, may show sufficient differences to separate generically the species having such widely different perfect stages.

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## HOMOTHALLISM IN PYTHIUM

T. C. VANTERPOOL

Investigations on the nature of the thallus in the Peronosporales have been confined to *Phytophthora* and *Peronospora*, in both of which complicated conditions exist within a single species. Studies on the sexual relations of species of *Pythium* with single zoöspore cultures have not been reported. Long cultural experience with the genus *Pythium*, however, has given no indication that heterothallism exists in the group. In spite, therefore, of investigating the obvious homothallism of *Pythium*, preliminary studies on single zoöspore cultures were undertaken. The majority of species of this genus are monoclinal, that is, the antheridia arise in more or less close proximity to the oogonium; in the diclinous species the antheridia arise from hyphae showing no traceable connection with the hypha bearing the oogonium or only extremely rarely. If heterothallic forms exist they would more likely be diclinous.

The work of Ashby (1, 2, 3), Narasimhan (9), Leonian (7) and others shows that in *Phytophthora* though some species are definitely homothallic others, such as the *P. palmivora* Butler group, may possess definitely homothallic strains, homothallic strains with heterothallic tendencies, heterothallic strains, and neutral or apparently sterile strains. More recently, Helena de Bruyn (4) has reported similar complicated conditions in the thallism of *Peronospora parasitica* (Pers.) Tul. De Bruyn inclines to the view, held by Leonian and others, that the heterothallic strains are not strictly unisexual, but possess the potentialities of both sexes, one sex being ordinarily dominant. It is not intended here to discuss the views or evidence on the rôle chemical substances may play in heterothallism in *Phytophthora* (cf. 6, 8).

The following table gives information on the species studied in the present investigation.

Fungus	Source	No. of single zoöspore cultures	Oöspore formation
<i>Pythium arrhenomanes</i> Drechsl.....	J. E. Machacek, Winnipeg. Isolated from wheat roots	39	Sparse
<i>P. Butleri</i> Subramaniam	S. F. Ashby, Imperial Mycological Institute	22	Moderate
<i>P. myriotylum</i> Drechsl..	Centraalbureau voor Schimmelcultures, Baarn	7	Sparse
<i>P. torulosum</i> Coker & Patterson.....	T. C. Vanterpool. Isolated from wheat roots in England	4	Good
<i>P. complectens</i> Braun...	M. Park, Ceylon. Isolated from turmeric ( <i>Curcuma longa</i> L.)	5	Good
<i>Phytophthora Cactorum</i> L. & C.....	S. F. Ashby	9	Good

The method of securing single zoöspore cultures of *Pythium* species now follows. Sterile Syracuse watch glasses, each containing two wheat-root tips in about 3 cc. distilled water, were inoculated with a small piece of cornmeal agar culture of the fungus, and kept at room temperature. After three days the water was changed. This was repeated on the fourth day and the cultures examined thereafter at half-hour intervals for swimming zoöspores. If these were found to be present, a few drops of water containing zoöspores were pipetted off and distributed on the surface of 2 per cent water agar in a Petri dish. If the zoöspores were numerous appropriate dilution in sterile water became necessary. After two hours or more when there was no free water on the agar, the dish was inverted on a microscope stage and a search made for zoöspores separated by several millimetres from the nearest neighbor. As germination of the spores had usually begun by this time, their detection was made easier. The position of each individual spore was marked with a small dot of Indian ink; the dish was then inverted and a disc of agar about 1.5 mm. in diameter cut out from directly above the dot of ink and transferred to another dish containing cornmeal agar. Then followed another microscopic examination to verify that only a single spore had been transferred with each disc of agar. Subsequently, cultures from these single zoöspores were studied separately for the

production of sexual organs and oöspore formation. Cultures of the parent strains were studied concomitantly.

In all the species studied the single spore cultures could not be distinguished from the parent and in every instance developed both oögonia and antheridia, and oöspores, the latter in some species somewhat sparsely, yet no more so than the parent culture. This difficulty of obtaining sexual organs in certain strains of *Pythium* is a common experience. It would appear, however, that sooner or later once the right cultural conditions are provided, sexual organs will form in strains which formerly failed to produce them. The experience of Rands and Dopp (10) is a case in point. They found that by using humic acid agar practically all of a large number of recalcitrant strains were induced to develop sexual organs.

From the foregoing evidence, it appears that all of the five species of *Pythium* studied, including the diclinous *P. arrhenomanes*, are homothallic (monoecious, hermaphroditic, self-fertile). The same is true for *Phytophthora cactorum*.

#### SUMMARY

The complex condition existing in the thallism of certain species of *Phytophthora* and *Peronospora* is pointed out. Strict homothallism is shown to exist in five species of *Pythium* studied. The method used in obtaining the single zoöspore cultures of *Pythium* is described in detail.

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## A FEW NEW ZOÖPAGACEAE DESTRUCTIVE TO LARGE SOIL RHIZOPODS

CHARLES DRECHSLER

(WITH 7 FIGURES)

Additional fungi referable to the Zoöpagaceae having been brought to light through inspection of old Petri plate cultures started from various decaying vegetable materials, three of the larger forms among them will be newly described herein. Like most members of the family previously made known, each of the three forms were found subsisting exclusively on a particular species of rhizopod; all other microscopic animals infesting the agar substrata consistently remaining unharmed. The enormous destruction suffered by the protozoan concerned in each instance—destruction amounting often to extermination of all active individuals present—suggests that the feeding operations of the Zoöpagaceae may have an important relation to the pronounced fluctuations in populations of soil protozoa disclosed when determinations of their numbers are made from day to day (1).

### COCHLONEMA MEGALOSOMUM

The most impressive of the three fungi was found killing off a large *Amoeba* in aging *Pythium* cultures to which had been added some pinches of decaying plant materials collected in open woods with a luxuriant undergrowth of coarse herbaceous weeds, near Beltsville, Md., early in October 1937. As even the smaller infected rhizopods measured about  $75\ \mu$  in diameter when drawn into an approximately rounded shape (FIG. 1, *A*, *B*), while the larger specimens of similar conformation often attained a width of  $125\ \mu$  (FIG. 1, *D*), the animals were of dimensions making them visible to the naked eye as minute specks peppered over the surface of the substratum. A thick pellicle surrounded the massive sarcode, whose pseudopodial protuberances it confined usually in broadly lobate contours. One (FIG. 1, *B*, *z*; FIG. 2, *A*, *z*; *B*, *z*),

two (FIG. 2, *C*, *y*, *z*) or three (FIG. 1, *D*, *x*, *y*, *z*) digestive vacuoles were often present, and contained always accumulations of somewhat large bacteria. The single large prolate ellipsoidal nucleus, measuring mostly 18 to 24  $\mu$  in length and 13 to 19  $\mu$  in width, revealed in healthy condition an outer hyaline layer surrounding a perceptibly darker central portion (FIG. 1, *A*, *n*; *B*, *n*; *C*, *n*; *D*, *n*; FIG. 2, *A*, *n*; *B*, *n*; *C*, *n*). Because of a close similarity in nuclear structure thus evident, there can be little doubt that the *Amoeba* concerned here is specifically identical with the one encountered earlier as the prey of a hyphomycete I then described as *Dactylella tylopaga* (4). This identity encourages the application again of the binomial *Amoeba verrucosa* Ehrenb., whereby, besides, the rhizopod is distinguished advantageously from the several animals that in accordance with a deplorably indiscriminate usage sanctioned in protozoological writings I have elsewhere discussed as *A. terricola* Greeff. With respect to outward shape and nuclear structure no less than with respect to shape and appearance of contractile and digestive vacuoles, the rhizopod conforms well to at least one of the specimens figured by Leidy as *A. verrucosa* (8: *pl. 3, fig. 36*), though differing certainly from some other specimens depicted as likewise illustrative of that species (8: *pl. 3, fig. 34, 38*).

Infection of the *Amoeba* is accomplished through germination of an adhering conidium. After the germ-tube has penetrated the pellicle and grown a short distance, usually not much in excess of 5  $\mu$ , into the granular sarcode, it gives rise to a terminal expansion (FIG. 1, *A*, *a*) into which are soon received the entire conidial contents. The globose body thus formed then becomes separated from the germ-tube, and begins autonomous growth within the animal's protoplasmic interior. At the beginning the young thallus (FIG. 1, *A*, *b*; FIG. 2, *A*, *a*) shows little to distinguish it from the thalli of other members of the Zoöpagaceae endoparasitic in Amoebae. A more pronounced distal widening than is known in any related form hitherto described becomes evident as the body elongates into the latter half of its first spiral turn (FIG. 1, *A*, *c*; FIG. 2, *B*, *a-e*). A maximum width is usually attained when the hypha has made one and one-half turns, a first bifurcation then intervening to reduce the width perceptibly in the two resulting

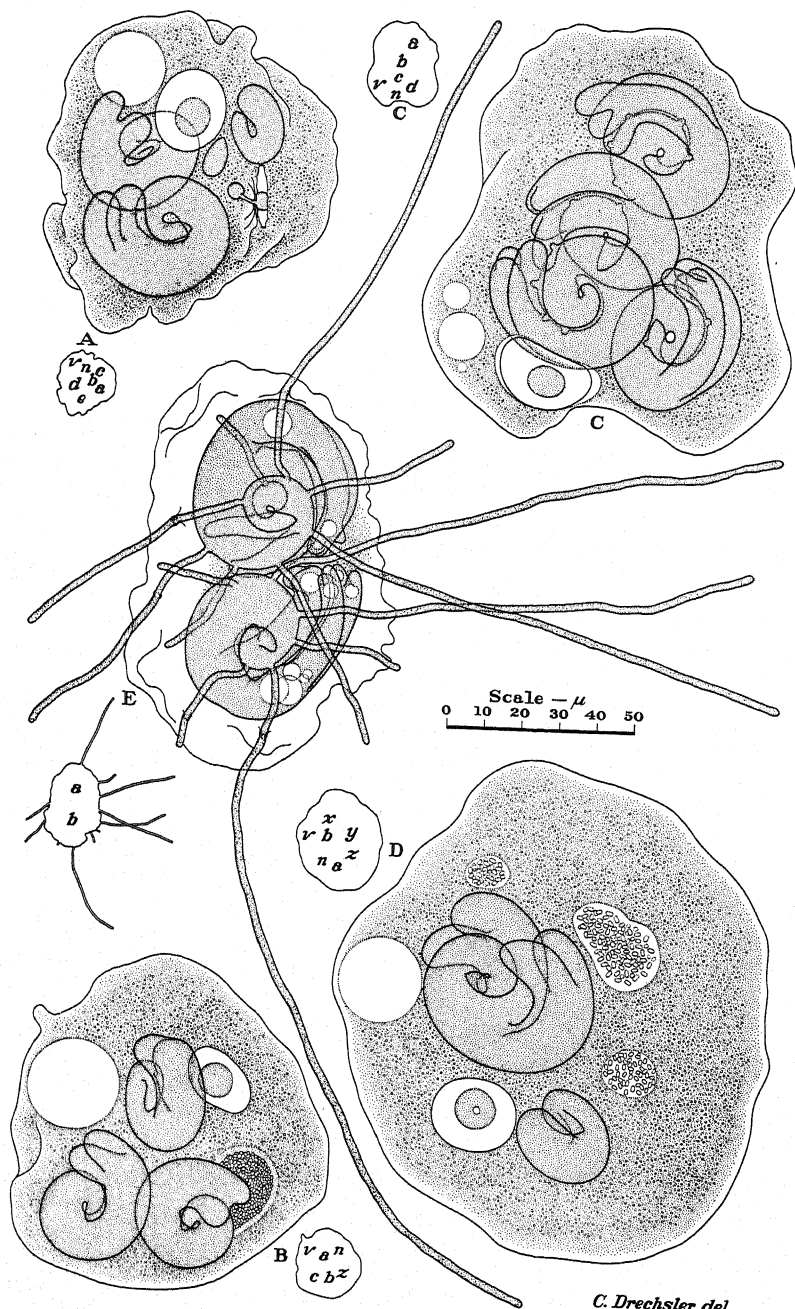


FIG. 1. *Cochlonema megalosomum*.

elements. In instances where a single thallus develops in a large animal, it may describe nearly three successive turns and bifurcate successively four times before the materials of the host are finally exhausted (FIG. 2, *E*: FIG. 3, *A*). Such well developed thalli, more than any other structure now known in the family, reveal the magnificence of form and dimensions that has long made the Zygomycetes a favorite group among mycological virtuosi. Bifurcation here often presents a peculiarity in that it frequently takes place in the plane of the first coil, rather than in a plane perpendicular thereto; so that the daughter elements, instead of being equidistant from and symmetrically placed relative to the axis of the first coil, are represented by an inner branch and an outer one. As a result of this peculiarity in branching, the well-developed thallus of the present species is usually disposed in a markedly flattened spiral rather than in a globose clew as are generally the thalli of *Endocochlus gigas* Drechsl. (5) and *Cochlonema megaspirema* Drechsl. (6).

The parasite regularly gives rise to profuse conidial apparatus. At a stage when the host animal, if weakened through expropriation in large part of its protoplasmic contents, yet remains capable of movement and continues to operate its contractile vacuole in an apparently normal manner, wart-like protuberances appear on the older or proximal portion of the thallus. Whenever the spiral vegetative body is of relatively small volume, as often when it shares the nourishment in an animal with a number of other similar bodies, these protuberances are restricted closely to the outer profile of the first coil, along which they are usually spaced at approximately equal intervals (FIG. 1, *C*, *a-d*). Apparently these protuberances undergo little change until the *Amoeba* has been quite disabled from advanced depletion of its substance, when they grow out into filaments (FIG. 2, *D*, *d*, *e*) thrusting their way through the pellicle (FIG. 1, *E*) and extending themselves more or less erectly into the air to heights often in excess of 0.5 mm. The aerial hyphae thus formed soon become converted into chains of conidia (FIG. 2, *E*); wherefore the fungus manifestly is to be referred to the genus *Cochlonema*.

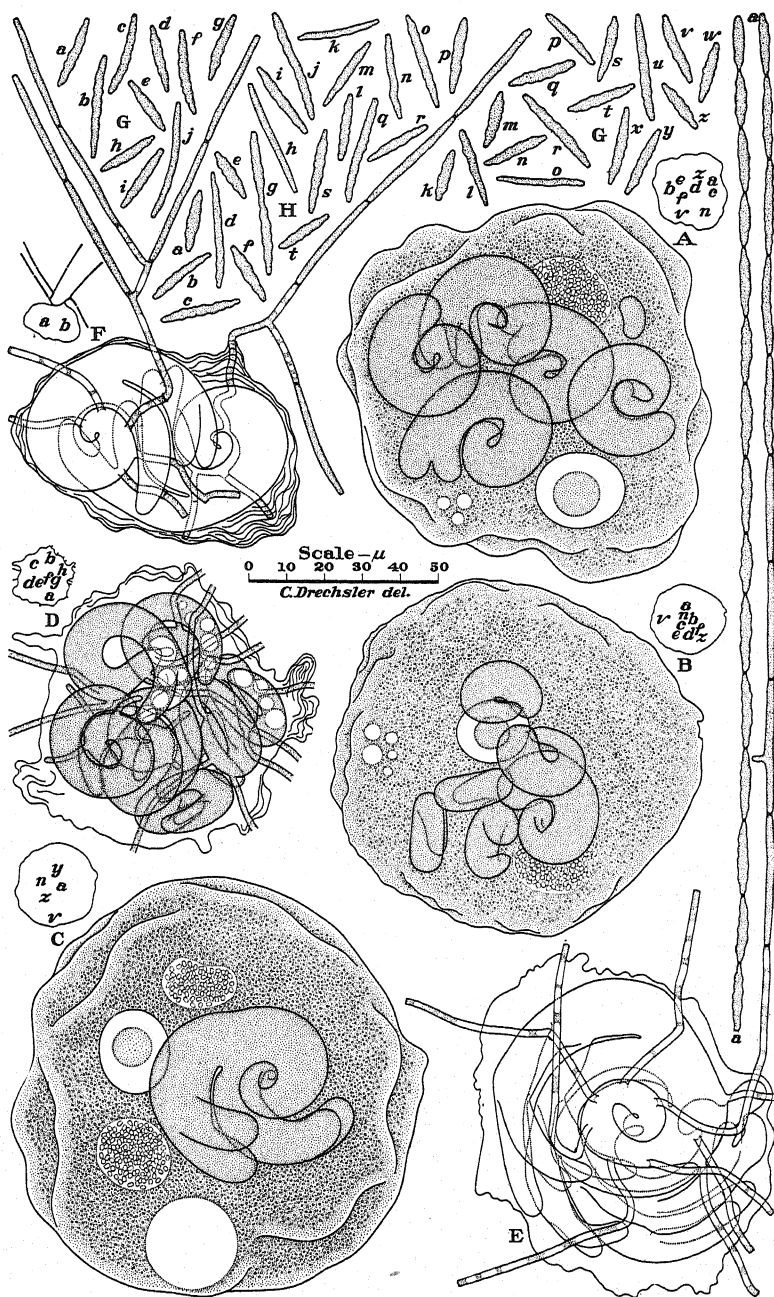
Like the homologous filaments of many allied catenulate forms, the continuous aerial hyphae show in their proximal portion little



external modification of any kind, but in their median and distal portions reveal pronouncedly warty sculpturing and regularly spaced constrictions (FIG. 3, C). Consequently, the basal members of a conidial chain are mostly cylindrical structures with very short connections, only slightly constricted (FIG. 2, F: FIG. 3, B, a-c; E, r), whereas the spores in median and distal positions are shorter, fusiform, pronouncedly warty bodies, tapering toward both bluntly rounded ends (FIG. 2, G, a-s; H, a-t: FIG. 3, E, a-q, s-s), where they are joined to their neighbors by narrow isthmi (FIG. 3, D). For the most part the connecting isthmi would seem not wholly empty, since the convex end walls of neighboring conidia often come into contact centrally with one another. In a general way, despite some differences in dimensions and shape, the conidia of the fungus recall those of the congeneric *Cochlonema megaspirema*.

Though large thalli, like the smaller ones, emit conidiiferous hyphae only from their proximal portions, they utilize for such emission a broader expanse of the surface available in these portions (FIG. 2, E: FIG. 3, A). Regardless of the size of the thallus, the progressive evacuation of protoplasmic contents accompanying production of fertile hyphae was never seen to be associated with the laying down of successive cross-walls so familiar in allied forms. The number and quantity of sporiferous filaments arising from an infected animal depends naturally altogether on the animal's size rather than on the number of thalli participating in its expropriation. Well developed specimens of the susceptible *Amoeba* often yield more than a dozen fertile hyphae (FIG. 3, A) that collectively may become visible to the naked eye as a minute whitish speck, and that under a microscope of low magnification appear loosely intertangled in an erect and often impressively luxuriant tuft. Disintegration of the aerial chains leaves hundreds of conidia strewn about on the substratum, each ready to adhere to any susceptible *Amoeba* that may by chance pass over it.

Among several hundred infected animals only three were observed to be instrumental in the development by the parasite of a sexual stage. Judging from this meager material, the fungus would seem to be strictly heterothallic. Thus in each of the seven pairs of sexual hyphae whose conjugation resulted in the seven

FIG. 2. *Cochlonema megalosomum*.

zygosporangia shown in figure 3, *F*, one hypha has its origin either in thallus *a* or thallus *b*, while the other has its origin either in thallus *c* or thallus *d*. Marked distal inflation of the sexual filaments provides a conspicuous feature in the morphology of the species. The zygosporangia, borne close to the union of the sexual hyphae, are to be reckoned among the largest known in the family. Their stubby protuberances invite comparison more especially with the homologous protuberances of *Cochlonema odontosperma* Drechl. (6), though lacking any cuspidal modification. In two of the thalli that had participated in sexual reproduction, a few heavy crosswalls were observed (FIG. 3, *F*, *a*, *d*), these presumably having been inserted as retaining septa at the time the vegetative elements were being evacuated.

A word meaning "large-bodied" is deemed appropriate as a specific name for the fungus.

***Cochlonema megalosomum* sp. nov.**

Hyphae alitae 4–20  $\mu$  crassae, semel vel quater repetite dichotomae, semel vel ter spiraliter convolutae, saepe praecipue ubicumque solitariae in animalibus magnis crescentes in spiram mirificam se circumvolventes. Conidia hyalina, 8–38  $\mu$  longa, 1.6–3.6  $\mu$  crassa, in catenulas 15–35-sporas, plus minusve erectas, 300–700  $\mu$  longas digesta, prope basin catenulae fere longiuscula, angusta, levia, cylindrata vel filiformia, in medio et prope apicem catenulae fere latiora, breviora, crasse verrucosa, fusiformia, utrimque abrupte rotundata. Hyphae zygosporiferae 25–75  $\mu$  longae, basi circa 1.5  $\mu$  crassae, sursum latescentes, apice 6–12  $\mu$  crassae, binae ex duabus hyphis alitis enatae. Zygosporangia sphaeroidea, saepe 13–16  $\mu$  crassa, 25–45 verrucis circa 1  $\mu$  altis basi circa .8  $\mu$  latis ornata; zygosporis maturis ignotis.

*Amoebam verrucosam* (sensu strictiore) enecans habitat in materiis plantarum putrescentibus prope Beltsville, Maryland.

Vegetative hyphae 4 to 20  $\mu$  wide, simple or repeatedly dichotomous up to 4 times, and wound spirally into a somewhat flattened coil of 1 to 3 successive turns. Conidia hyaline, 8 to 38  $\mu$  (average 20.5  $\mu$ ) long, 1.6 to 3.6  $\mu$  (average 2.6  $\mu$ ) wide, formed in numbers from 15 to 35 in more or less erect chains often 300 to 700  $\mu$  long—those in the proximal portion of a chain usually long, narrow, smooth, cylindrical to filiform—those in the middle and distal portions of a chain shorter, wider, rather coarsely warty, fusiform, abruptly rounded at the ends. Zygophoric hyphae 25 to 75  $\mu$  long, approximately 1.5  $\mu$  wide at the base, widening to a diameter of 6 to 12  $\mu$  at the apex, those of each conjugating pair arising from separate vegetative hyphae, each becoming divided by a

FIG. 3. *Cochlonema megalosomum*.

septum placed 20 to 30  $\mu$  below its apex; zygosporangium formed close to the union of the sexual hyphae, subspherical, sessile, usually 13 to 16  $\mu$  in diameter, ornamented with 25 to 45 thimble-like protuberances about 1  $\mu$  in height and 0.8  $\mu$  in basal width; mature zygospores unknown.

Destructive to *Amoeba verrucosa* (*sensu strictiore*) it occurs in decaying herbaceous plant materials in open woods near Beltsville, Md.

In some of the cultures in which *Cochlonema megalosomum* was found multiplying, it encountered competition from two other fungi. One of these fungi, unquestionably a member of the Zoöpagaceae, captured numerous specimens of *Amoeba verrucosa* by adhesion to sparse continuous mycelial filaments mostly about 2  $\mu$  wide, and intruded into each captive an extensively branched, bushy haustorium most similar to the haustorium of *Zoöpage mitospora* Drechs. (7). In many instances the fungus captured animals already infected by *C. megalosomum*; both of the organisms unconcernedly preceeding with their normal development side by side, and in apparently congenial relationship dividing the protoplasmic materials of the rhizopods between them.

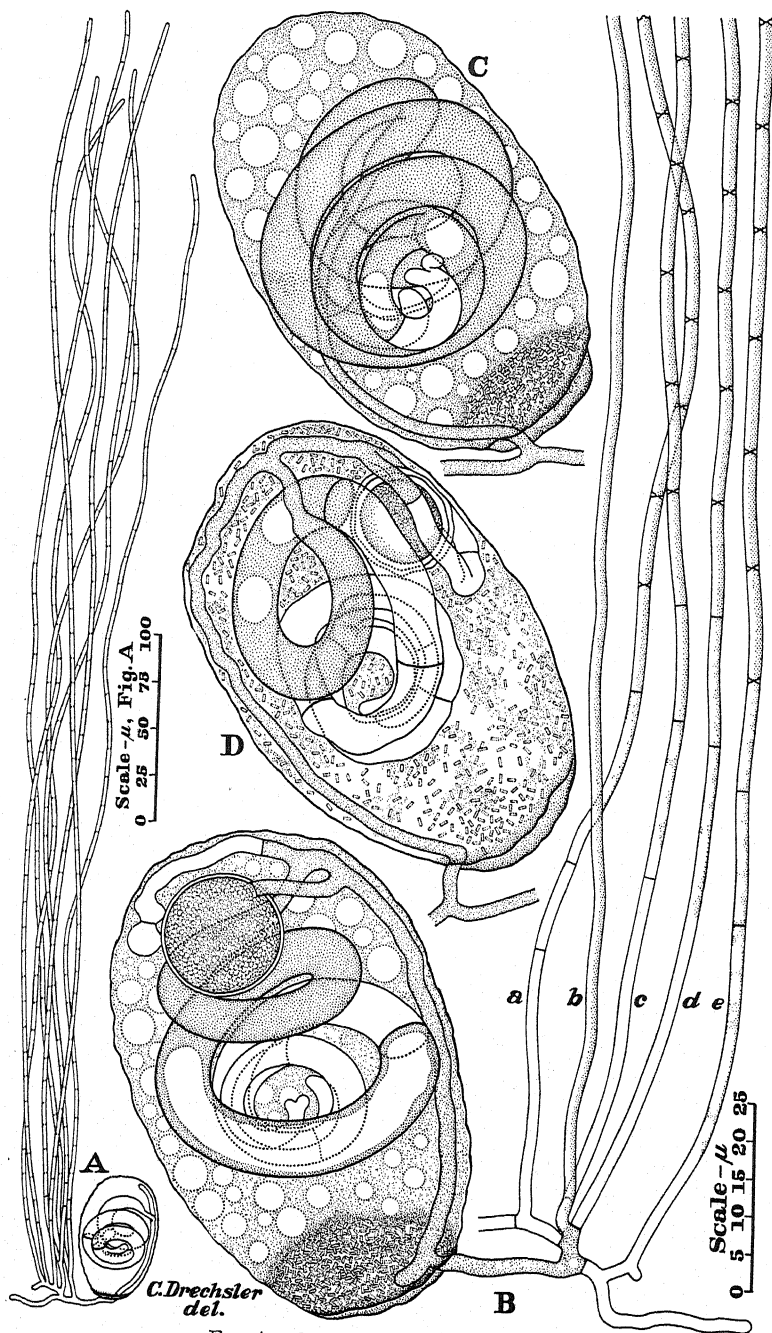
The other of the two fungi competing with *Cochlonema megalosomum* has likewise become known only by its vegetative stage, which is, however, of truly remarkable character, consisting of narrow filamentous hyphae that singly pursue conspicuously straight-forward courses on the surface of the substratum for distances varying mostly between 0.5 mm. and 5 mm. before bifurcating abruptly and symmetrically at angles of approximately 120 degrees. Each of the resulting elements repeats the prolonged straight-forward course and geometrical bifurcation of its parent, with the result that an exceedingly sparse arachnoid mycelial network is soon extended far over the substratum. Any specimen of *Amoeba verrucosa* captured on a filament of the predacious zoöpagaceous form in close proximity to one of the conspicuously straight-forward hyphae, is promptly invaded by a branch from that hypha, and depleted of its protoplasmic material by a copious, somewhat inflated, apparently septate, ramifying haustorial system arising from the branch. Such haustorial elements as may have been intruded into the animal by the zoöpagaceous form are caused to

degenerate completely, the newcomer thus excluding the true captor from further utilization of its prey. Now and then, also, a specimen of *A. verrucosa* disabled by *C. megalosomum* was found invaded by a branch from the arachnoid fungus, but as disablement of an animal by the endoparasite usually does not occur until the fleshy contents have been largely depleted, the intruder here developed only meager haustorial apparatus which exerted no noticeable ill effects on the massive spiral thalli nearby.

#### COCHLONEMA BACTROSPORUM

Among the larger testaceous rhizopods that multiply in old agar plate cultures following the addition of decaying herbaceous vegetable detritus, is a member of the genus *Heleopera* Leidy agreeing well with the description of *H. sylvatica* Penard (9: p. 389-390), and accordingly referred to that species. After a few weeks of development under favorable conditions, the animal often attains populations in excess of 100 individuals. In a number of cases such flourishing colonies of the rhizopod then suffered a rapid reduction of living specimens that apparently always ended in complete extermination.

That the agent responsible for the devastation might most probably be a parasite belonging to the Zoöpagaceae was immediately suggested by the presence of more or less erect, isolated tufts, each composed of 2 to 10 tall aerial filaments arising from the substratum in immediate proximity to one of the animals (FIG. 4, *A*). On closer examination the aerial filaments were indeed revealed as consisting either of chains of rod-like conidia (FIG. 4, *B*, *a*, *c*, *d*, *e*: FIG. 5, *A*, *a-c*) or of continuous hyphae manifestly representing younger stages in the development of such chains (FIG. 4, *B*, *b*). While the individual conidia rather strongly resembled those of *Cochlonema cylindricum* Drechsl. (6) in shape, they offered easily recognizable differences not only in their greater dimensions, but also in the persistence of a somewhat papillate protrusion at each of their ends. These curious polar modifications have their origin in the partial delimitation of the conidia from one another through localized evacuation of protoplasm in such a manner as to leave an empty groove surrounding a narrow axial isthmus; separation of

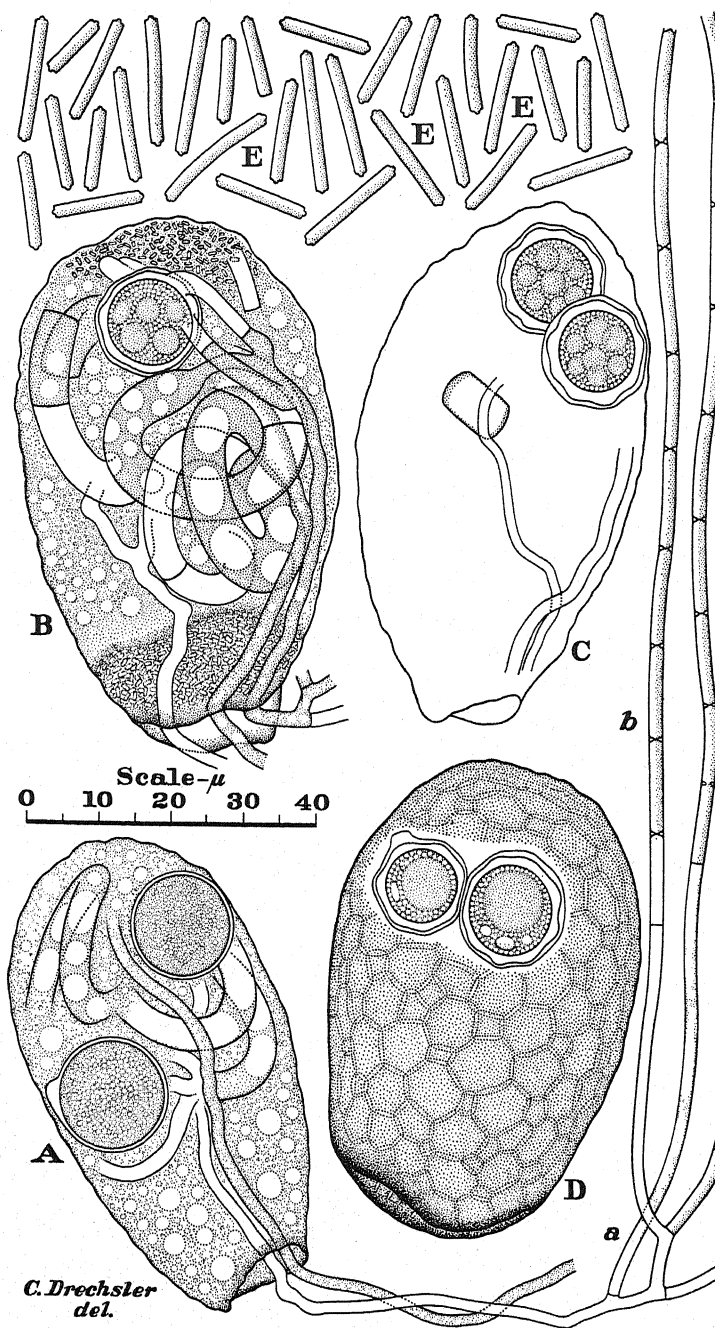
FIG. 4. *Cochlonema bactrosporum*.

adjacent spores being then completed by the insertion of a cross-wall at the middle of the isthmus. It appears possible that conidial development may follow an essentially similar course in *C. cylindricum*, even if the spores of that form show little distinctive outward modification.

As was expected from the character of the conidial apparatus that they represented, the tufts of aerial filaments were in each instance found to have a close hyphal connection with a spiral thallus inside the specimen of *Heleopera sylvatica* nearby (FIG. 4, A, B: FIG. 5, A). A few thalli that could be followed satisfactorily under the difficult optical conditions brought about by the murky, vacuolate consistency of the surrounding protoplasm, showed very handsome helicoid arrangement: the vegetative hypha in its first turn, usually nearest the fundus of the host, widening gradually to a maximum diameter maintained throughout the grandiose second turn, then gradually diminishing in width in the narrowing distal turns closest to the mouth of the animal (FIG. 4, B, C). Branching was observed only in the distal portion of the thallus, a first bifurcation often occurring at the beginning of the fourth turn, and a second, where present, at the beginning of the fifth turn. The meager and inconspicuous branching is hardly sufficient to counteract the deceptive impression that the vegetative body usually conveys of having grown opposite to its actual direction of growth. After the initiation of reproductive development, the thallus is progressively evacuated of protoplasm from the distal toward the proximal portion, and retaining septa are laid down in positions successively closer to the proximal end (FIG. 4, A-D). The single reproductive filament arising from the proximal end of the thallus often needs to thrust its way almost the entire length of the animal before it can emerge from the oral opening. Once outside of its host, the reproductive filament sends a few short branches into the substratum, and then gives rise successively to the aerial hyphae that, except for a sterile basal part, become converted, likewise successively, to chains of cylindrical conidia.

Aside from its copious display of conidial apparatus, the fungus also reproduces sexually. Approximately a third of the animals seen destroyed were partly utilized in the development of zygospores. The sexual spores of the parasite, unlike any of the



FIG. 5. *Cochlonema bactrosporum*.

homologous bodies hitherto made known in related species, usually are formed within the host—more often indeed, in positions near the fundus than near the mouth, and only rarely in the substratum a short distance from the mouth. As frequently an animal in which a zygospore was visible contained only a single thallus, it would seem that the fungus is definitely homothallic (FIG. 4, *B, D*). Apparently the zygosporangium is formed at the union of two rather short sexual elements, which in some cases (FIG. 4, *B*) arise separately from the reproductive filament short distances from its origin, and in other cases arise through bifurcation of a single branch similarly given off by the reproductive filament close to its attachment (FIG. 4, *D*). On attaining its definitive size the zygosporangium consists of a smoothly spherical cell, densely filled with coarsely granular contents (FIG. 4, *B*; FIG. 5, *A*). The coarsely granular protoplasmic structure is retained during the earlier stages in the development of the zygospore proper, when there is deposited within the zygosporangial wall a thicker wall having perceptible sigillate thickenings. These thickenings become slightly more pronounced as maturation proceeds with accompanying formation and enlargement of reserve vacuoles, often from 5 to 10 in number (FIG. 5, *B, C*). These vacuoles later coalesce, so that in its fully mature condition the zygospore of the fungus under consideration, like that of other members of the Zoöpagaceae, shows an internal organization more familiar in oöspores: a large central reserve globule being surrounded by a parietal protoplasmic layer of coarsely granular texture, in which is imbedded on one side an oblate ellipsoidal refringent body (FIG. 5, *D*).

As in all instances where an animal clearly was parasitized by a single thallus, only a single reproductive filament could be seen emerging from the oral opening and no more than one zygospore could be discerned developing inside. It is believed that plural production of these structures from individual thalli, if occurring at all, is at least infrequent. The presence of two or three reproductive filaments (FIG. 5, *A, B, C*), or of two zygosporangia (FIG. 5, *A, C, D*) would therefore, in the main, seem to imply the presence of a corresponding number of thalli. Plural infection would appear to be concerned also in cases where spiral hyphal coils, only

partly visible, are found in markedly confused arrangement (FIG. 5, A, B).

A term made up from words meaning "staff" and "seed," respectively, and intended to be descriptive of the cylindrical conidium, is deemed appropriate as a specific name for the fungus.

### *Cochlonema bactrosporum* sp. nov.

Hyphae alitae 2-8  $\mu$  latae, primo latescentes deinde minuentes, ter vel quater in spiram primo latescentem deinde minuentem cocleatim convolutae, saepius semel vel bis sursum dichotomae, unusquisque ex basi hypham fili-formem 1.5-2.5 crassam evolvens quae non solum in aera extra testam animalis invasi 2-10 hyphas erectas 300-750  $\mu$  altas deinceps profert sed subinde etiam binos ramos zygosporiferos intra testam emittit; hyphis aeriis se vertentibus in conidia catenulata, hyalina, levia, cylindrata, 9-19  $\mu$  longa, 1.6-1.9  $\mu$  crassa, utrimque ad instar verruculae rotundata; ramis zygosporiferis 10-45  $\mu$  longis, circa 2  $\mu$  crassis; zygosporangiis sphaeroideis 13-17  $\mu$  crassis, membrana postea circum zygosporam collapsa; zygosporis paulo flavidis, plerumque 11-15  $\mu$  crassis, maturitate ab membrana 0.5-1.8  $\mu$  crassa in extremitate ad instar sigillorum undulata circumseptis.

*Heleoperam sylvaticam* necans habitat in reliquiis plantarum putrescentium prope Beltsville, Maryland.

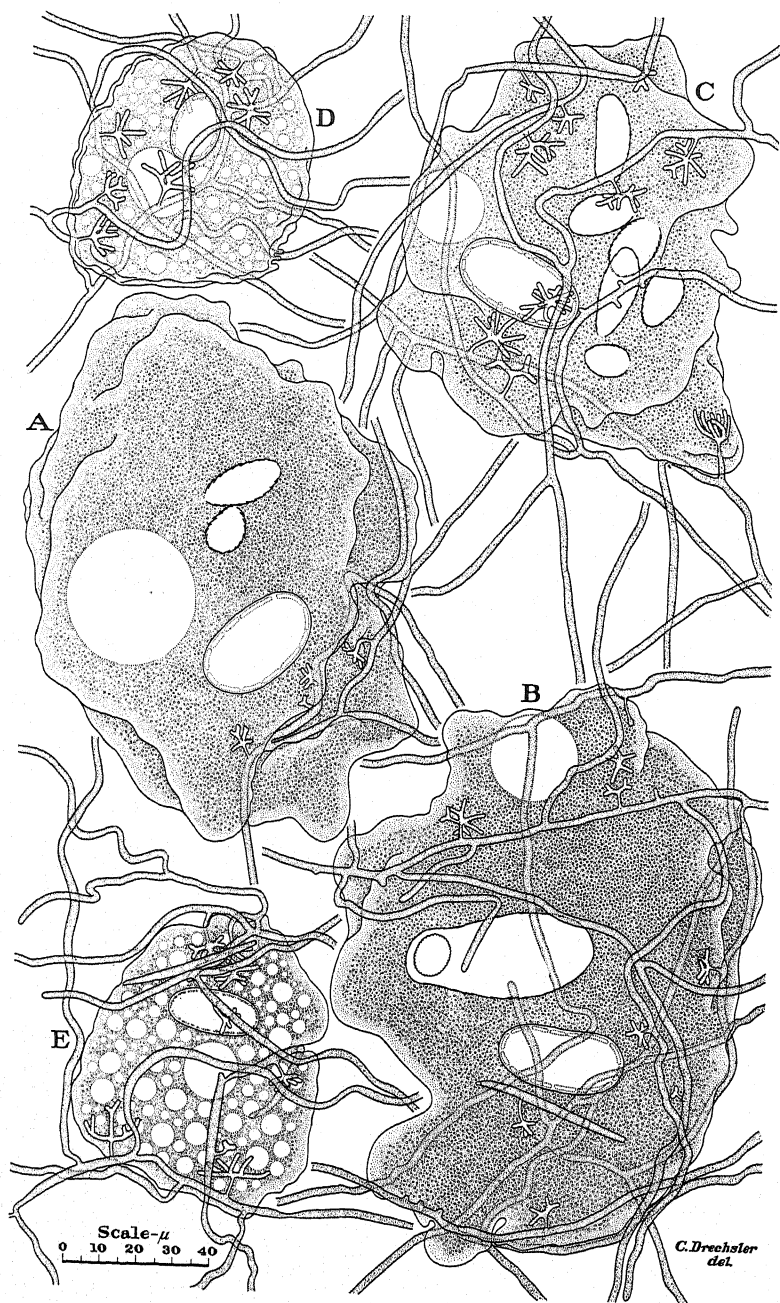
Vegetative hypha disposed in a more or less extended helicoid spiral of 3 or 4 successive turns; attaining a width of 5 to 8  $\mu$  in the second and widest turn that often measures 35 to 40  $\mu$  across; in the successively smaller third and fourth turns often narrowing to a diameter of 2 or 3  $\mu$ ; sometimes branching dichotomously once or twice in its distal portion; putting forth from its base a filament 1.5 to 2.5  $\mu$  wide that not only produces successively 2 to 10 erect aerial hyphae 300 to 750  $\mu$  high outside the testa of the host animal, but in addition sometimes gives rise, most often inside the testa, to paired zygomorphic branches: each of the aerial hyphae becoming converted into a chain of hyaline conidia 9 to 19  $\mu$  (average 14.3  $\mu$ ) long, 1.6 to 1.9  $\mu$  wide, smooth, cylindrical, with a small wart-like protuberance at both ends; the zygomorphic hyphae, 10 to 45  $\mu$  long and about 2  $\mu$  wide, after conjugation bearing a subspherical zygosporangium 13 to 17  $\mu$  in diameter and surrounded by a wall originally smooth but later collapsing rather closely about the yellowish zygosporangium, which measures usually 11 to 15  $\mu$  in diameter and at maturity is surrounded by a wall 0.5 to 1.8  $\mu$  thick with sigillate undulating outer contour.

Destroying *Heleopera sylvatica* it occurs in decaying plant remains on moist ground near Beltsville, Md.

## ACAULOPAGE MARANTICA

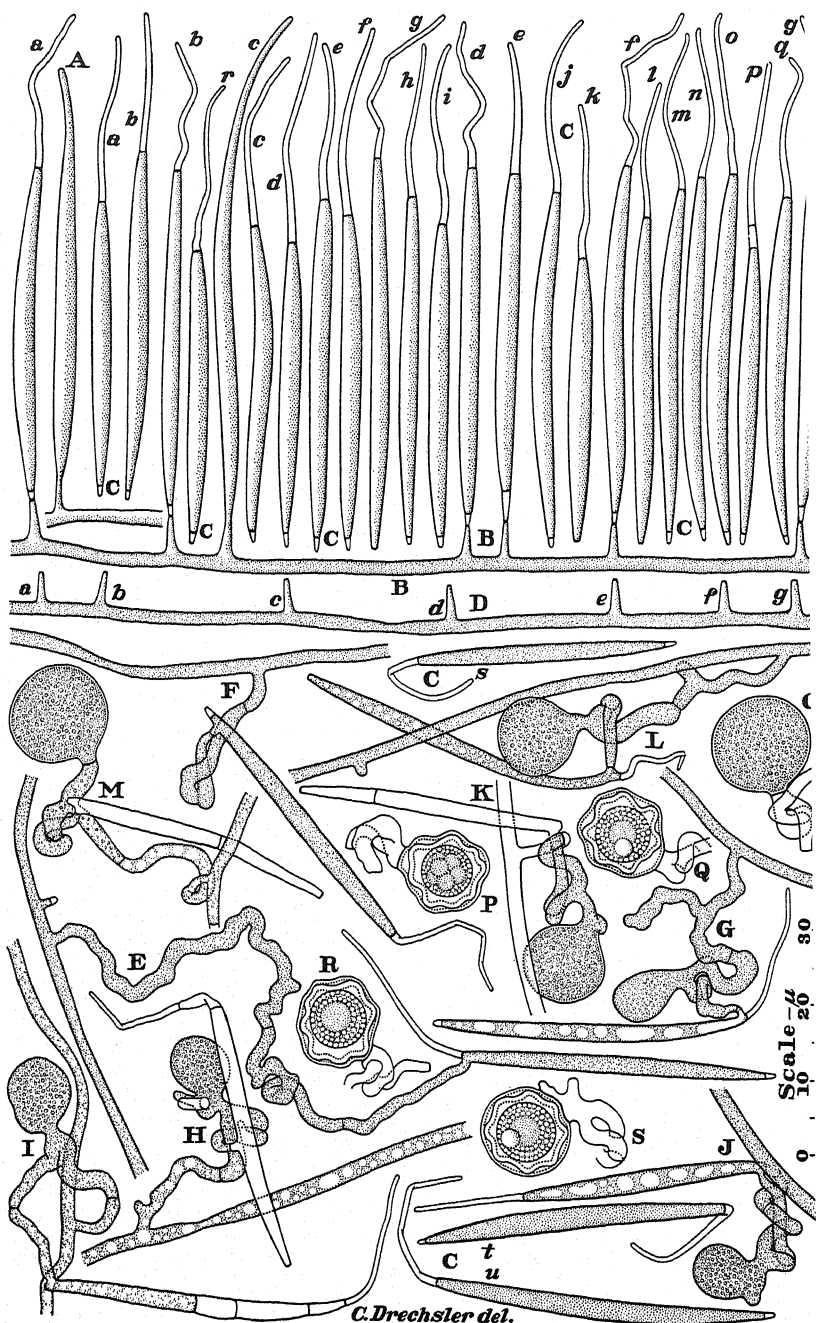
One of the old maize-meal agar plate cultures, in which *Cochlonema megalosomum* made its appearance, showed also the development of another relatively coarse though morphologically less remarkable member of the Zoöpagaceae. This second fungus subsisted exclusively on a large *Amoeba* that often attained a length of  $150\ \mu$  when drawn into its usual slightly elongated form (FIG. 6, A, B, C). The animal was further distinguished by a thickish pellicle cast in boldly undulating contours over broad pseudopodial protrusions, as well as by a single large prolate ellipsoidal nucleus often  $30$  to  $35\ \mu$  long and  $15$  to  $20\ \mu$  wide, the generally homogeneous consistency of which was interrupted close under the delimiting membrane by a parietal layer of noticeably darker material, appearing in profile as disjunctive rods arranged end to end. From these morphological features the identity of the rhizopod with the one previously found serving *Endocochlus gigas* as prey and *C. megaspirema* as host was sufficiently evident; wherefore it will be referred to as *Amoeba terricola* Greeff (*sensu strictiore*).

Nourished on an abundant supply of living shelled rhizopods, including mainly *Trinema enchelys* Ehrenb. (FIG. 6, B) and a small species of *Euglypha* (FIG. 6, A-C), the large *Amoeba* had multiplied until more than 100 individuals were present. The animals, which because of their size were clearly visible to the naked eye, first invited attention through an abnormally dense concentration of some dozens of specimens in a small area adjacent to a pinch of decaying herbaceous material planted there some weeks earlier—the crowded tract presenting a rather densely stippled macroscopic appearance. Examination under the microscope revealed a relationship wholly analogous to that described earlier (2) as existent between the large but decidedly different *Amoeba* then provisionally designated as *A. terricola* III, on the one hand, and the predacious *Zoöpage planera* Drechsl. on the other. At the margin of the crowded area specimens of *A. terricola* (*sensu strictiore*) were seen adhering to hyphae of an aseptate, irregularly disposed mycelium, some of the hyphae, indeed, being enveloped here and there in pseudopodial folds (FIG. 1, A). The small number of stalked, dichotomously branched haustoria thrust into the individ-

FIG. 6. *Acaulopage marantica*.

ual animal, together with the apparently undiminished density of the granular protoplasm, the unceasing extension and retraction of pseudopodia in attempted locomotion, the normal discharge of the contractile vacuole and the healthy appearance of the large nucleus, gave evidence that expropriation of the rhizopod was still in an early stage. By far the larger number of closely congregated animals showed much more extensive enwrapment by the mycelium (FIG. 6, *B*, *C*). A conspicuously irregular disposition of the enveloping branched filaments, and their presence not only on the under side of each captive but on its upper exposed side as well were to be explained undoubtedly by the persistent wallowing movements through which the animal, instead of freeing itself, merely succeeded in enmeshing itself more securely. Intrusion of additional haustoria consequent to more extensive mycelial engagement hastened the depletion of the captive's fleshy contents: the diminishing cytoplasm becoming pronouncedly vacuolate (FIG. 6, *D*); the large nucleus betraying internal degeneration in a gradual obliteration of its interrupted darker layer (FIG. 6, *E*). Eventually nothing remained visible but the empty collapsed pellicle, within which the haustoria had disappeared from view when their protoplasmic contents had been withdrawn into the parent mycelial filaments.

The fungus reproduced asexually by giving rise to an abundance of elongated fusiform conidia, appendaged at both ends. Development of the individual conidium was found to begin with the production from a superficial hypha of an erect continuous outgrowth narrowing for a short distance above its base, then rather markedly widening upward for a somewhat greater distance, and then again gradually narrowing throughout the distal two-thirds of its length (FIG. 7, *A*; *B*, *c*). From the slender apical portion embracing about a third of the length of the outgrowth the contents were then retracted, and a confining septum was deposited to delimit the filled from the empty part. In the meantime a cross-wall had been inserted in the narrow isthmus a short distance above the base of the outgrowth, a small segment immediately above the cross-wall being thereupon emptied of protoplasm, and another confining septum deposited (FIG. 7, *B*, *a*, *b*, *d-g*). Through disarticulation at the lowest septum, the conidium with its short empty

FIG. 7. *Acaulopage marantica*.

basal stipe, its spindle-shaped living cell, and its more or less collapsed, narrow, empty distal appendage (FIG. 7, *C*, *a-f*, *h-j*, *m-u*) became separated from the short erect sterigma. Except for its considerably greater dimensions, and for the presence of its empty basal stipe, which, for that matter, was occasionally absent (FIG. 7, *C*, *g*, *k*, *l*), the conidium strongly resembles that of the obviously congeneric *Acaulopage rhicnospora* Drechsl. (3), though the close bristling arrangement of the erect spores on the prostrate filaments would seem more especially suggestive of *A. cercospora* Drechsl. (5).

Sexual reproduction of the fungus took place abundantly in the culture, and as in many related forms appeared to be further encouraged when portions of occupied substratum were removed to glass slides for microscopic examination. Of each pair of zygo-phoric branches, one always came from a mycelial filament, while the other consisted of a germ-tube from a conidium. Instances of conjugation between two branches arising from mycelial hyphae, or of conjugation between two germ-tubes were never seen among the hundreds of units of sexual apparatus that came under observation. Contact of the zygophoric branches was found associated usually with only slight twisting, and was regularly accompanied by the deposition of cross-walls partitioning off the paired gametangia (FIG. 7, *E*, *F*). The subspherical zygosporangium was developed generally on a rather short stalk arising at a variable but usually inconsiderable distance from the union of the sexual hyphae (FIG. 7, *E-M*). Delimitation of the organ by a basal septum (FIG. 7, *M*, *O*), and conversion of the contents into a zygospore with a sculptured wall of undulating profile well separated from the sporangial envelope except at the projecting crests, followed a sequence familiar in most other members of the family (FIG. 7, *P-S*). In its mature condition the zygospore showed a relationship of parts hitherto found only in species of *Endocochlus*—the inner surface of the thick undulate wall appearing distinctly separated from the subspherical protoplast (FIG. 7, *P-S*). The protoplast, as in related forms, revealed, on full maturation, a single central reserve globule surrounded by a parietal layer of uniform granules; and imbedded in the granular layer was usually discernible a globular refringent body (FIG. 7, *Q-S*).



Though the fungus was active in a culture that permitted abundant development also of *Cochlonema megalosomum*, it was never observed to capture specimens of *Amoeba verrucosa*, nor, on the other hand, was *C. megalosomum* observed to parasitize *A. terricola* (*sensu strictiore*). Like the endoparasite, however, and, indeed, to a greater extent and more frequently, it suffered from interference by the sparsely arachnoid, geometrically disposed mycelial form of intrusive propensities. The arachnoid form by itself was evidently no more able to attack *A. terricola* than *A. verrucosa*, but when once a specimen of the former was captured, it extended within the captive its characteristically swollen, branching haustorial system, the presence of which promptly caused degeneration in the haustoria of the predacious species under consideration, just as it brought about degeneration in the haustoria of the unindentified predacious form often destructive to *A. verrucosa*.

A term meaning "withered" and believed to be aptly descriptive of the conidia of the fungus, with their frequently collapsed distal appendages, is offered as an appropriate specific name.

***Acaulopage marantica* sp. nov.**

Mycelium ramosum, effusum; hyphis hyalinis, saepe irregulariter flexuosis, 1-2.8  $\mu$  crassis, ad animalcula inhaerentibus, vulgo ea extense circumplectantibus, pelliculam eorum perforantibus, haustoria intus evolventibus quae carnem exhauriunt; haustoriis pedicellatis, pedicello saepius 2.5-6  $\mu$  longo, 0.6-1  $\mu$  crasso, apice abrupte latescente, semel vel ter repetite bifurco, ita 2-8 ramulos divaricatos, 1-10  $\mu$  longos, 0.8-1.6  $\mu$  crassos ferente. Conidia hyalina, ex sterigmatis erectis, vulgo 3-5  $\mu$  altis, basi 1-1.5  $\mu$  crassis, sursum attenuatis, apice 0.5-0.8  $\mu$  crassis, inter se saepius 5-35  $\mu$  distantibus oriunda, vulgo ex partibus tribus composita: parte supera vacua, 15-30  $\mu$  longa, basi 0.8-1.3  $\mu$  crassa, sursum leniter attenuata, saepius plus minusve marcida vel collapsa; parte media protoplasmatis repleta, elongato-fusoidea, 33-52  $\mu$  longa, 2.4-3.1  $\mu$  crassa; parte infera vacua, 0.8-4  $\mu$  longa, sursum 0.6-1.2  $\mu$  crassa. Hyphae zygosporiferae 10-75  $\mu$  longae, 1-3  $\mu$  crassae, saepe plus minusve irregulariter flexuosae, 10-15  $\mu$  ab junctione septo divisae, interdum aliquantum inter se circumplectantes, una ex hypha mycelii, altera ex conidio germinanti oriunda. Zygosporangia primo levia, sphaeroidea, vulgo 12-14  $\mu$  crassa, maturitate membrana circa zygosporam laxè collapsa; zygospora flavida, globosa, circa 9-12  $\mu$  crassa, maturitate membrana late verrucosa vel sinuosa, cellulam viventem sphaeralem 6.5-8  $\mu$  latam laxè circumdante.

*Amoebam terricolam* (*sensu strictiore*) capiens consumensque habitat in materiis plantarum putrescentibus prope Beltsville, Maryland.

Mycelium branched, spreading; vegetative hyphae colorless, often irregularly flexuous, 1 to 2.8  $\mu$  (mostly about 2  $\mu$  wide), ad-

hering to and often becoming extensively wrapped about minute animals, penetrating the pellicle of each captive and intruding haustoria to appropriate the fleshy contents; haustoria pedicellate, the pedicel often 2.5 to 6  $\mu$  long, 0.6 to 1  $\mu$  wide, abruptly widening and bifurcating one to three times at wide angles to terminate in 2 to 8 branches 1 to 10  $\mu$  long and 0.8 to 1.6  $\mu$  wide. Sterigmata arising abruptly from superficial hyphae at intervals of 5 to 35  $\mu$ , erect, 3 to 5  $\mu$  high, 1 to 1.5  $\mu$  wide at the base, tapering upward to a width of 0.5 to 0.8  $\mu$  at the tip whereon is borne erectly a single conidium. Conidia hyaline, each usually composed of three parts: the distal part empty, 15 to 30  $\mu$  (average 21.6  $\mu$ ) long, 0.8 to 1.3  $\mu$  (average 1.1  $\mu$ ) wide at the base, tapering upward slightly, often more or less collapsed; the middle part filled with protoplasm, elongate spindle-shaped, 33 to 52  $\mu$  (average 42.9  $\mu$ ) long, 2.4 to 3.1  $\mu$  (average 2.7  $\mu$ ) wide; the lowest part obconical, empty, 0.8 to 4  $\mu$  (average 1.5  $\mu$ ) long, 0.6 to 1.2  $\mu$  wide at its distal attachment. Zygomorphic hyphae 10 to 75  $\mu$  long, 1 to 3  $\mu$  (mostly about 2  $\mu$ ) wide, often more or less irregularly flexuous, the two of a pair sometimes slightly intertwined, one commonly arising as a branch from a mycelial filament, the other commonly consisting of a germ-tube from a conidium, each with a distal portion, or gametangium, 10 to 15  $\mu$  long, set off by a septum. Zygosporangium at first smoothly subspherical and commonly 12 to 14  $\mu$  in diameter, at maturity collapsing loosely about the zygospore; the latter yellowish, 9 to 12  $\mu$  in diameter, its wall, at maturity broadly verrucose and pronouncedly sinuous in contour, loosely surrounding a subspherical living cell usually 6.5 to 8  $\mu$  in diameter.

Capturing and consuming *Amoeba terricola* (*sensu strictiore*) it occurs in decaying plant remains near Beltsville, Md.

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#### EXPLANATION OF FIGURES

FIG. 1. *Cochlonema megalosomum*; drawn with the aid of a camera lucida to a uniform magnification;  $\times 500$  throughout. *A*, specimen of *Amoeba verrucosa* in a condition of active motion, showing besides its nucleus, *n*, and its contractile vacuole, *v*, five thalli of the fungus, *a-e*: *a* representing a very early stage, protoplasmic materials still being received from the externally adhering conidium; *b*, a stage soon after separation from the parent conidium; *c*, a thallus of one turn with marked distal widening; *d* and *e*, older and more massive thalli, each of which has undergone a single bifurcation. *B*, specimen of *A. verrucosa* in active state, containing three bifurcating thalli of the fungus, *a-c*, besides its own nucleus, *n*, its contractile vacuole, *v*, and a digestive vacuole, *z*, inclosing many ingested bacteria. *C*, specimen of *A. verrucosa* containing besides its nucleus, *n*, and its contractile vacuole, *v*, four thalli of the fungus, *a-d*, of which two, *b* and *d*, are twice dichotomous throughout, the others, *a* and *c*, showing a second dichotomy in only one of the two elements resulting from the first bifurcation; in each of the thalli hyphae are just beginning to grow out from the outer contour of the older or proximal portion. *D*, a large specimen of *A. verrucosa* in active state, showing a rather young thallus, *a*, and an older, larger, successively twice bifurcate thallus, *b*, of approximately two successive turns, besides revealing its own nucleus, *n*, its contractile vacuole, *v*, and three digestive vacuoles, *x-z*, surrounding groups of ingested bacteria. *E*, pellicle of *A. verrucosa*, the contents of which have been depleted by two thalli, *a* and *b*, that have put forth, respectively, eight and six sporiferous hyphae of variable lengths.

FIG. 2. *Cochlonema megalosomum*; drawn with the aid of a camera lucida to a uniform magnification;  $\times 500$  throughout. *A*, specimen of *Amoeba verrucosa* in active condition, infected with a very young thallus, *a*, and five much larger thalli, *b-f*; *n*, nucleus of host animal; *v*, contractile vacuole in incipient stage of expansion; *z*, digestive vacuole containing numerous ingested bacteria. *B*, specimen of *A. verrucosa* in state of active locomotion, containing six thalli, *a-f*; *n*, nucleus of host animal; *v*, contractile vacuole in incipient stage of expansion; *z*, digestive vacuole containing numerous ingested bacteria. *C*, specimen of *A. verrucosa* in a state of active locomotion, though burdened with the large thallus *a*; *n*, nucleus of host animal; *v*, contractile vacuole; *y* and *z*, digestive vacuoles containing numerous ingested bacteria. *D*, shrunken pellicle of *A. verrucosa*, the protoplasmic contents of which have been consumed by the eight thalli, *a-h*; from

seven of the thalli, *b-h*, sporiferous hyphae have begun to grow out. *E*, wrinkled pellicle of *A. verrucosa* surrounding an empty envelope of a large spiral thallus whose protoplasmic contents have been used up in the production of eight conidiiferous filaments; of these filaments seven are represented, from lack of space, only by their sterile basal parts, the other one being shown in two sections connecting at the common point *a*. *F*, wrinkled pellicle of *A. verrucosa* surrounding two largish empty envelopes of thalli that have been exhausted of contents in the production of conidiiferous hyphae, whereof, from lack of space, only proximal portions are shown. *G*, *a-s*; *H*, *a-t*, conidia showing variations in dimensions, shape and sculpturing.

FIG. 3. *Cochlonema megalosomum*; drawn with the aid of a camera lucida to a uniform magnification;  $\times 1000$  throughout. *A*, collapsed pellicle of *Amoeba verrucosa*, the fleshy contents of which have been consumed in the growth of an unusually large thallus, now represented only by an empty aseptate envelope, owing to the depletion of its protoplasm in the production of eighteen conidiiferous hyphae; from lack of space only the proximal portions of the fertile hyphae are shown. *B*, a conidiiferous filament branching within the host pellicle, and showing long, smooth conidia in the proximal portions of spore chains. *C*, distal portion of growing aseptate conidial filament, showing regularly spaced constrictions and coarsely warty sculpturing. *D*, distal portion of mature conidial chain, showing narrow contact of adjacent conidia at the axis of each isthmus. *E*, conidia, showing variations in dimensions, shape and sculpturing. *F*, collapsed pellicle of *A. verrucosa* within which are found four empty thalli of the parasite, *a-d*; from these thalli have been produced zygosporic hyphae that have united in pairs by their greatly widened apices to give rise to the handsomely mammillated zygosporangia *e-k*; as the two zygosporangia *e* and *k* have each resulted from union of paired hyphae arising from thalli *a* and *c*, the two zygosporangia *f* and *i* each from union of paired hyphae arising from thalli *b* and *d*, and the three zygosporangia *g*, *h* and *j* each from union of paired hyphae arising from thalli *a* and *d*, presumably the thalli *a* and *b* are of one sexual constitution, and the thalli *c* and *d* of the opposite sexual constitution.

FIG. 4. *Cochlonema bactrosporum*; drawn with the aid of a camera lucida to a uniform magnification. *A*, depleted specimen of *Heleopera sylvatica* containing the empty envelope of a single thallus that has used up its contents in the production of a tuft of seven conidial chains;  $\times 250$ . *B*, specimen of *H. sylvatica* containing a thallus that has given rise inside of the testa to a young but fully grown zygosporangium, and outside of the testa to a tuft of five erect asexual reproductive filaments, *a-e*, of which, for lack of space, only the proximal portions are shown—while the continuous filament *b* is in a young growing condition, the others, *a*, *c*, *d* and *e*, consist largely of conidial chains;  $\times 1000$ . *C*, specimen of *H. sylvatica* containing a well developed thallus of the parasite, from whose younger branched extremity protoplasm is being withdrawn for the extension of conidial filaments outside of the testa;  $\times 1000$ . *D*, specimen of *H. sylvatica* containing a thallus from which the protoplasmic contents have mostly been withdrawn

to provide for the formation within the animal's testa of a zygospore, and of conidiiferous filaments outside of the testa;  $\times 1000$ .

FIG. 5. *Cochlonema bactrosporum*; drawn with the aid of a camera lucida to a uniform magnification;  $\times 1000$  throughout. A, specimen of *Helcopera sylvatica* within which are indistinctly visible several curving portions of hyphae belonging probably to two separate thalli; two zygosporangia of definitive size, but still immature, are more clearly visible inside, as are also two hyphae growing out of the animal's mouth, one of which has given rise to three conidial chains, a-c, whereof, from lack of space, only basal portions are shown. B, specimen of *H. sylvatica* containing presumably three thalli of the parasite, each extending a separate filament through the oral opening to produce conidial chains externally; one having, in addition, produced a zygosporangium with nearly mature zygospore, inside of the testa. C, depleted specimen of *H. sylvatica* within which a small segment of thallus, two outgrowing filaments, and two zygosporangia with nearly mature zygospores are visible. D, depleted specimen of *H. sylvatica*, showing inside of the testa with its characteristic arrangement of plates, two fully mature zygospores, each surrounded by its sporangial membrane. E, conidia, showing variations in dimensions and shape.

FIG. 6. *Acaulopage marantica*; drawn to a uniform magnification with the aid of a camera lucida;  $\times 500$  throughout. A, specimen of *Amoeba terricola* (*sensu strictiore*) in active condition, entangled on one side with adhesive mycelial filaments, from which four haustoria have been thrust through the pellicle into the sarcod; within the animal are shown also the fully expanded contractile vacuole, the large nucleus, and two depleted testae of ingested rhizopods referable apparently to the genus *Euglypha*. B, living specimen of *A. terricola* extensively inwrapped in adhesive mycelial filaments, from which collectively eight haustoria have been thrust into the sarcod exclusive of the haustorium arising from an adhering conidium; within the animal's body are shown also its contractile vacuole, its ellipsoidal nucleus, and the large empty testa of an ingested specimen of *Trinema enchelys*. C, a living specimen of *A. terricola* extensively inwrapped with adhesive mycelial filaments from which collectively ten haustoria have been thrust into the sarcod; within the animal are distinguishable its contractile vacuole, its ellipsoidal nucleus, and six empty testae of ingested rhizopods belonging apparently to a small species of *Euglypha*. D, a rather small specimen of *A. terricola* securely entangled in adhesive mycelial filaments; the abundance of vacuoles distributed through the sarcod indicating a somewhat advanced stage of protoplasmic depletion, accomplished by means of the seven well developed haustoria. E, another smallish specimen of *A. terricola* entangled in adhesive mycelial filaments; from these filaments and a germinating conidium have been intruded eight haustoria, which have brought about a well advanced stage of protoplasmic depletion in the animal, as is manifest from the presence of very numerous vacuoles, and from the partial obliteration of the interrupted parietal layer in the nucleus.

FIG. 7. *Acaulopage marantica*; drawn to a uniform magnification with the aid of a camera lucida;  $\times 1000$  throughout. A, portion of prostrate

hypha on which is borne an erect process later to develop into a conidium. *B*, a prostrate filament with seven conidia, *a-g*, borne erectly on separate erect sterigmata; all of the conidia are mature except one, *c*, which though of approximately definitive size, has not been partitioned off from its sterigma, nor undergone evacuation either in its proximal or in its distal part. *C*, *a-u*, conidia, showing variations in dimensions and shape of living cell, empty basal stipe, and empty distal appendage. *D*, prostrate hypha with seven erect sterigmata, *a-g*, all denuded of their conidia. *E*, *F*, young sexual apparatus; in each unit a zygophoric hypha arising as a branch from a mycelial filament has fused apically with another zygophoric hypha arising as a germ-tube from a fallen conidium. *G-L*, sexual apparatus in somewhat later stages of development, likewise showing origin of each unit through union of one zygophoric hypha, arising as a branch from a mycelial filament, with another consisting of a germ-tube from a conidium. *M*, sexual apparatus at still later stage, showing the fully grown zygosporangium set off from its supporting stalk by a septum. *O*, fully grown zygosporangium set off by a septum from evacuated zygophoric elements. *P*, nearly mature zygosporangium lying within the somewhat collapsed sporangial membrane, to which is shown attached the empty envelope of the united gametangia. *Q-S*, mature zygosporangia, each lying within its slightly relaxed sporangial envelope.

# EMPUSA INFECTIONS OF THE HOUSE-FLY IN RELATION TO MOISTURE CONDI- TIONS OF NORTHERN IDAHO

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The common fungus, *Empusa Muscae*, infecting house-flies is a very familiar parasite. Infected flies may be found in late spring or early autumn adhering to window-panes or mirrors, surrounded by a dusty halo of discharged spores. In some cases it is possible to find live insects sticking to the glass, trying to break away from the mycelium which surrounds them.

The infection of the fly begins with the adherence of viable spores to the surface of the abdomen where they may go through a period of dormancy or germinate immediately (6). The degree of infection depends on the amount of spores picked up by the fly. Several factors may be instrumental in causing conidial formation after a long period of dormancy within the insect host; but experiments performed at Moscow, Idaho, indicate that environmental conditions, mainly humidity, greatly influence conidial formation. These experiments were conducted over a period of seventeen months, during the latter part of 1936 and throughout 1937, experiencing varying weather conditions.

In these experiments several hundred flies were used, and two different methods were employed to minimize contamination by other fungus forms and to induce germination of most of the *Empusa* conidia.

To obtain cultures of the fungus, a modification of the method used by Sawyer (5) was employed. Several flies were glued thoroughly to a pane of glass which was then inverted over half a moisture chamber containing moistened cotton. The glass was sealed tightly to the chamber, and the whole apparatus set in a warm, well-lighted spot. The speed with which the spores germinated and mycelium broke from the abdomen of the fly, varied from three to eight days. This may have been due to the varying amounts of spores present within the insect.

The second method employed was the use of several well-known nutrient solutions, distilled water and tap water. As a complete set-up, 100 small vials were half-filled with a nutrient solution and a fly placed in each. In every case similar results were obtained, although much contamination by *Mucor*, *Rhizopus*, and *Penicillium* resulted. Knop's, Detmer's, Pfeffer's, Crone's (4), and Sach's and Czapek's (3) nutrient solutions were used. A sugar-starch solution as follows was also employed.

Water .....	1000 gms.
Soluble starch .....	2 gms.
Sucrose .....	1 gm.

Table I shows the relation of *Empusa* infections to the amount of precipitation covering the period during which tests were made. The results can be understood more clearly if the total amount of rainfall and departure from the normal for each month is presented.

TABLE I  
RELATION OF *Empusa* INFECTIONS TO TOTAL AMOUNT OF RAINFALL<sup>1</sup> FROM  
SEPTEMBER 1936 TO NOVEMBER 1937

Month	Total ppt., inches	Departure from normal	Number of flies tested	Number of flies infected	Percentage infection
Sept.....	1.18	+0.02	20	1	5.0%
Oct.....	0.30	-1.30	40	0	0.0%
Nov.....	0.24	+2.78	40	1	2.5%
Dec.....	2.74	+0.06	0	—	—
Jan.....	3.60	+0.66	0	—	—
Feb.....	2.77	+0.62	0	—	—
Mar.....	2.25	+0.05	0	—	—
Apr.....	3.81	+2.29	0	—	—
May.....	0.69	-1.19	120	48	40.0%
June.....	2.92	+1.56	100	48	48.0%
July.....	0.23	-0.38	0	—	—
Aug.....	0.49	-0.23	0	—	—
Sept.....	0.79	-0.37	200	3	1.5%
Oct.....	1.51	-0.09	200	0	0.0%
Nov.....	3.60	+0.58	200	0	0.0%

<sup>1</sup> Precipitation data from Carter (1, 2).

In the fall of 1936, Idaho experienced the driest weather in the history of the weather bureau. The results obtained showed that a total of 2 per cent of the flies studied were infected with *Empusa Muscae*. In the winter and spring of 1937, there was a complete reversal of moisture conditions. From January to April, northern



Idaho experienced some of the wettest weather since 1894. During May, although precipitation fell off considerably, the saturated condition of the soil, swollen creeks, and remaining snow, kept the humidity high. Again in June rainfall was very heavy. The wet conditions produced heavy casualties among the house-flies. A total of 220 flies were studied showing the percentage of infection to be 43.6. From July to November the amount of rainfall was very low. The atmosphere as a result was very dry, and although a total of 600 flies were studied only three infections were obtained. The percentage for this period was 0.5.

Direct correlation was found to exist between the amount of precipitation in this area and the *Empusa* infections. During the dry months, few or no infected flies were found and in humid or rainy months an abundance was obtained. The prevalence of *Empusa Muscae* infections, therefore, seems to vary directly with the amount of rainfall.

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# A COMPARISON OF MYCETOZOA FAUNA IN SANDSTONE AND LIMESTONE RE- GIONS OF AUGUSTA COUNTY, VIRGINIA

LLOYD G. CARR

Collecting the Mycetozoa in southeastern Augusta County has disclosed a number of unusual forms, and has revealed that the types of genera present in one region compared to another vary according to the lime content of the soil. This investigation is the first ecological study of the Mycetozoa in relation to their lime requirement.

Forms have been secured from two general localities: one situated in a sandstone region near the base of the Blue Ridge Mountains, the other in a limestone region well out in the Shenandoah Valley. The forms in the sandstone region select habitats on old logs and sphagnum moss which is scattered around the numerous ponds that appear there. Numerous springs feed into these ponds which are formed as a result of limestone sinks. However, there is no outcropping of limestone in the present area as it is completely covered by overthrusting and many feet of talus and wash at the foot of the Blue Ridge. Therefore, the limy material that lies many feet below the sandstone wash is unavailable to the use of the lime genera of the Mycetozoa. The ponds usually present a gradual incline on the sides, and are well hidden in the flat woods. The numerous springs near these ponds form boggy shallows on the edges, affording excellent pockets in which leaves and other vegetable materials collect. In the process of decay these materials hold much moisture. All of these factors are favorable to the growth of the Mycetozoa.

Many of the more familiar species of the Mycetozoa are present here. *Didymium nigripes* var. *xanthopus* Lister grows in abundance on sphagnum moss. *Lamproderma arcyryonema* Rost., *Comatricha typhoides* Rost., *Arcyria denudata* Wettstein, *A. cinerea* Pers., *A. digitata* Rost., *A. nutans* Grev., *Stemonitis*

*axifera* Macbr., *S. splendens* Rost., *Trichia persimilis* Karst., *T. scabra* Rost., and *Hemitrichia vesparium* Macbr. are familiar forms on decayed logs. A few forms appear to confine themselves to brush and leaf heaps. *Oligonema nitens* Rost. and *Leocarpus fragilis* Rost. select heaps of this type. *Trichia lutescens* Lister appears in the sandstone region representing the first record for its appearance in the east and the second record in North America.<sup>1</sup> It was found on the inner bark of a fallen oak tree which had decayed.

Upon examination of the lime species occurring in the sandstone region, the fructifications are observed to develop in scanty quantities of small sporangia. A small number of lime species was collected over a wide area in the sandstone region. *Physarum columbinum* Sturgis, *P. oblatum* Macbr., *P. viride* Pers., *P. globuliferum* Pers., *Badhamia lilacina* Rost., *B. orbiculata* Rex., *Fuligo septica* Gmelin., *Didymium nigripes* var. *xanthopus*, and *Leocarpus fragilis* Rost. are forms occasionally seen in the region. Also, the lime genus *Diderma* is represented here with a few conspicuous forms, *Diderma floriforme* Pers., *D. radiatum* Morg., *D. testaceum* Pers., and *D. effusum* Morg. It appears that the best material represented in the sandstone region is from the genera incorporating no lime in their structures.

The "lime genera" collected in these regions were *Badhamia* Berk., *Physarum* Pers., *Fuligo* Haller, *Craterium* Trentep., *Leocarpus* Link, *Diderma* Pers., *Diachea* Fries in the Physaraceae, and *Didymium* Schrad. and *Mucilago* Adanson in the Didymiaceae.

Considering the finds from the sandstone region on a percentage basis, it is calculated that 41.9 per cent of the 31 forms collected are included in the "lime general," whereas 58.1 per cent require no lime.

The Shenandoah Valley lies essentially in a limestone region. Here and there hills or monadnocks rise upward from the valley plain. Often the sides of the hills are indented with sinks. Gibson's Hill, near Barterbrook, possesses two sinks. One sink is in the form of a big bowl wooded on each side with oaks, maples, cherries, and the beaked alder. The edges of the bowl slant to a small pool of water. On one edge there are precipitous cliffs with

<sup>1</sup> The only other report for this form in North America is from Colorado.

shelf-like projections. These furnish pockets for the collection of leaves and other vegetable materials which hold considerable moisture. As the water moves over the rocks and seeps through the leaves, it carries with it calcium carbonate which collects in the leaf pockets. Here the lime species of the Mycetozoa are numerous in well-developed, robust fructifications. Several of the rarely collected forms appear in the sink. It is possible that the available quantity of lime and the copious moisture had something to do with their occurrence here.

*Physarum Listeri* Macbr. is present and has a double sporangial wall consisting entirely of lime.<sup>2</sup> Since the double wall has not been noted previously, the material proves to be the most representative of the form. *Physarum serpula* Morgan, a rare form, *P. contextum* Pers., *P. lateritium* Morg., *P. melleum* Mass., and *P. sinuosum* Link occur here on leaves.

*Diderma Trevelyani* Fries, a rare form in the east, was found on decayed leaves of *Quercus marilandica* Muench in one of the numerous pockets.<sup>2</sup> When its sporangial wall breaks in a petaloid fashion, it resembles a miniature water lily that has just opened. This species has a three-walled sporangium, and the middle one is studded with crystalline lime so as to form an unbroken wall. As its requirement for lime is rather high, the available lime in a region would determine its distribution. It should be looked for in limestone sinks. *Diderma testaceum* spreads in much larger plasmodiocarps on leaves in the sink than it does in sandstone regions.

*Diachea splendens* Racib. was fruiting extensively near the base of the sink. This form is not often collected, but may be looked for with some degree of success in limestone sinks. It was found in all of the sinks which I examined. *D. bulbillosa* Lister and *D. leucopoda* Rost. are also present.

*Craterium minutum* Fries, an odd form, with goblet-shaped fruiting bodies was discovered. A thin coat of powdery lime was noted on the surface of the lids.

Only a few forms requiring no lime have been observed here. These are *Hemitrichia serpula* Rost. and *Arcyria nutans* Grev.

<sup>2</sup> Hagelstein, Robert. Notes on the Mycetozoa. *Mycologia* 30: 336-353. 1938.

Determining the percentages, it is found that 11.7 per cent of the 17 forms collected in the limestone region contain no lime in their structures, whereas 88.3 per cent are typical members of the lime genera.

Considering the total number of lime forms, 53.5 per cent were from a small area in the limestone region, whereas 46.5 per cent occurred over an extensive area in the sandstone region. Of the forms requiring no lime, 90 per cent were found in the sandstone areas, while 10 per cent were present in the limestone region.

In connection with this study, Mr. Robert Hagelstein of the New York Botanical Gardens writes: "I have always found that the calcareous forms are in greater abundance and far more robust in limestone regions than in regions without limestone, taking as an example Long Island where I reside, and which is of glacial origin without much lime."

#### SUMMARY

The results present several interesting facts: the lime loving genera are abundant in limestone regions, while in others they are lacking or are not prolific over wide areas; and, the forms using no lime in their structures appear in abundance in localities where the lime content of the soil is low. It is indicated that the fruiting bodies of the lime genera growing in an abundance of lime are better developed. Limestone sinks are favorable spots where odd and rare forms of the lime genera are localized.

#### ACKNOWLEDGMENT

Appreciation is expressed to Dr. Ivey F. Lewis, University of Virginia, and to Mr. Robert Hagelstein for checking identifications.

# PORIA ANDERSONII AND POLYPORUS GLOMERATUS, TWO DISTINCT HEART-ROTTING FUNGI

W. A. CAMPBELL & ROSS W. DAVIDSON

(WITH 2 FIGURES)

## INTRODUCTION

Pure-culture studies of wood-rotting fungi, which are conducted as an aid in distinguishing macroscopically similar rots and determining their relative importance, frequently also clarify the taxonomic relationships of the species involved. Such is the case with *Poria Andersonii* (Ellis & Ev.) Neuman and *Polyporus glomeratus* Peck, two species frequently isolated in a decay study, which to date have not been clearly separated by mycologists and pathologists.

Peck (10) in 1873 described *P. glomeratus* and it has since been recognized by most mycologists as a well-defined species of *Polyporus*. Unfortunately the taxonomic position of *P. Andersonii* has not been so well established. In 1890 Ellis and Everhart (5) described *Mucronoporus Andersoni* as a resupinate polypore fruiting under the bark of an "oak log." Only a fragment of the type specimen is still in existence in The New York Botanical Garden and it appears to be as originally described. This fungus has since been confused with *P. glomeratus*. In fact Ellis and Everhart themselves were in part responsible for this confusion because they issued exsiccati sets in which they included a resupinate form of *P. glomeratus*, from maple, under the name *M. Andersoni*. In 1894 Underwood (11) described a fungus similar to *M. Andersoni* on the under side of poplar logs in Indiana as *Polyporus (Poria) xanthosporus*. Murrill (7) in 1916 described a new genus *Xanthoporia* based on Ellis and Everhart's *Mucronoporus Andersoni*. Neuman (8) listed the Ellis and Everhart species as *Poria Andersonii* and gave *Poria xanthospora* as a synonym. Lloyd at first separated *P. glomeratus* from *P. xanthospora*, as he classified his

specimens, but later (6) declared the latter to be a resupinate form of *P. glomeratus*. Baxter (1, 2) apparently came to the same conclusion.

Ellis and Everhart's failure to distinguish between the two species is clearly shown by examination of their exsiccati under the name *Mucronoporus Andersoni*. Their specimen 3101, North American Fungi, is really *P. glomeratus*, and was collected on *Acer rubrum* L. at Shelpot Creek near Wilmington, Delaware, in 1893. Their number 3101b in the same series is *P. Andersonii* collected on poplar logs in Ohio, 1895.

#### CHARACTERISTICS IN NATURE

All specimens of *P. glomeratus* examined by the writers occur on the outside of the bark on maple and beech, usually with some indication of a pileus. On the other hand, *P. Andersonii* apparently always develops under the bark or thin wood layer of dead standing snags or down logs of several hardwood species. Although it is reported on willow, poplar and hickory, it is found most commonly on species of oaks. None of the specimens shows any indication of a pileus. *P. glomeratus* sporophores contain easily demonstrated large setal hyphae in the trama of the tubes (FIG. 1, G), which are illustrated by Overholts (9), whereas *P. Andersonii* has much smaller setal hyphae (FIG. 1, C). In addition, the distribution of such setal hyphae in sporophores of *P. Andersonii* is more erratic and in most cases difficult to demonstrate.

Several specimens of *Poria Leei* (Murr.) Sacc. & Trott., collected on oaks in California, were examined and the sporophores appeared to be identical with *P. Andersonii*. Isolations made from a sporophore collected on tanbark oak by E. E. Morse near Berkeley, California, were similar in all respects to those secured from *P. Andersonii* in the East.<sup>1</sup>

*P. Andersonii* resembles, in manner of fruiting and in appearance of the sporophores, the *Poria* recently described by Campbell and Davidson (4) as the cause of the sterile conks on birch.<sup>2</sup>

<sup>1</sup> This specimen was sent originally to L. O. Overholts who forwarded a portion to the writers for culturing.

<sup>2</sup> There seems to be little question but that this *Poria* is the same as *Poria obliqua* (Pers.) Bres. found on birch and other hosts in Europe.

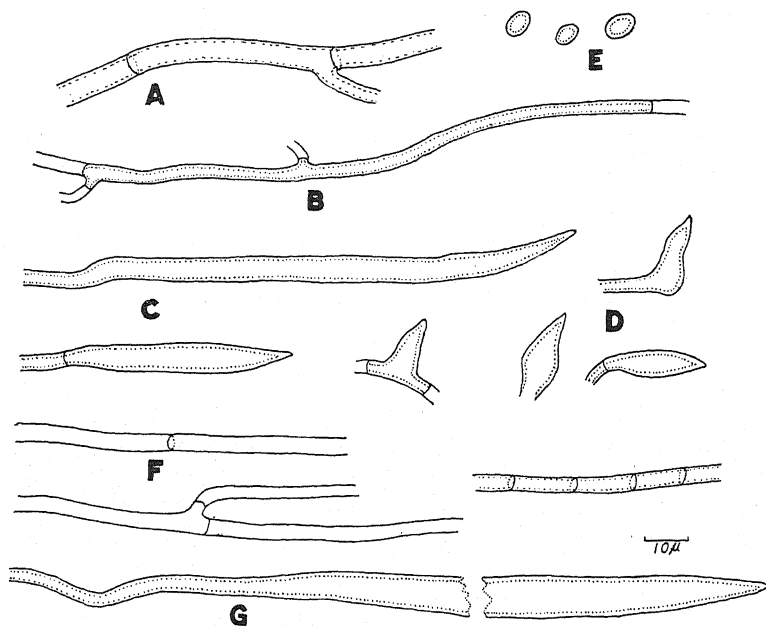


FIG. 1. A-E, *Poria Andersonii*. A, submerged hyphae; B, superficial hyphae; C, setal hyphae; D, bulbous setae; E, basidiospores. F and G, *Polyporus glomeratus*. F, submerged hyphae; G, setal hyphae.

However, *P. Andersonii* has yellowish-green spores,  $5-8 \times 4-5 \mu$  and spores of the latter are hyaline or only occasionally pale-yellow,  $6-10 \times 4-6 \mu$ . The two species are also very different in culture.

#### CULTURAL CHARACTERISTICS AND DISTRIBUTION

##### PORIA ANDERSONII

*Petri-dish cultures*: Growth slow forming in 7 days a mat 2-3 cm. in diameter.<sup>3</sup> Mat either cottony or silky-cottony, thin, and not raised above the agar or fine woolly to felty, raised and compacted, primuline yellow,<sup>4</sup> mustard yellow and apricot yellow to as dark as antimony-yellow and yellow-ochre.

<sup>3</sup> All descriptions based on mats grown on 1.5 per cent Difco malt with 2 per cent agar, in diffused light at room temperature averaging approximately 26° C.

<sup>4</sup> Ridgway, R. Color standards and color nomenclature. 1914.



In 14 days mat 4.5–7 cm. in diameter (FIG. 2, *A, B*), very variable, usually raised, compacted, with definite concentric rings, often showing pronounced segments, mostly felty but occasionally long cottony about inoculum; light-orange-yellow to yellow-ochre, raw sienna and buckthorn-brown; margin either rising abruptly from the agar or with a thin, appressed, yellowish or almost colorless zone of advancing growth. Marginal characters very variable as some cultures may show thin marginal growth and dark colored staled areas over all or only a portion of the surface.

Hyphae staining with eosin, 2–5  $\mu$  in diameter (FIG. 1, *A*), no clamps; from staled areas under center, yellowish, collapsed, non-staining, with numerous cross-walls and often broken up into irregular lengths; fibrous hyphae thick-walled, dark brown, 2–4(–5)  $\mu$  in diameter (FIG. 1, *B*); long dark-brown setal hyphae common in some cultures, rare in others, up to 8  $\mu$  in diameter and 250  $\mu$  long (FIG. 1, *C*); bulbous setae common in compacted, staled areas and in fruiting structures (FIG. 1, *D*); basidiospores occasionally formed in poroid areas, ellipsoid, smooth, yellowish-green, 5–8  $\times$  4–5  $\mu$  (FIG. 1, *E*).

*Temperature relations:* Optimum temperature for growth approximately 35° C. Average diameter of mats in 7 days at constant temperatures,<sup>5</sup> in dark, as follows: 1.0 cm., 20°; 3.1 cm., 25°; 5.2 cm., 30°; 5.5 cm., 35°; slight growth, 40°.

*Test-tube cultures:* In 14 days mat raised, fine woolly to felty, or appressed-felty, mustard-yellow and apricot-yellow to as dark as antimony-yellow and yellow-ochre.

In 28 days mat on slant compacted woolly to felty, yellow-ochre to buckthorn-brown and raw sienna; on agar cylinder lighter, mustard-yellow to antimony-yellow and yellow-ochre, often with pronounced zones, tough, forming a heavy film which is difficult to tear with a needle. An occasional isolate will form well-developed pores on a raised mycelial cushion at the lower end of the slant.

*Flask cultures:* The mycelium, on maple and oak blocks, is at first yellow, cottony, becoming in 10 months compacted ochraceous

<sup>5</sup> Dishes kept 1 day at room temperature before placing in incubator. To prevent drying of the medium, especially at high temperatures, the Petri dishes were placed, 4 to a can, in tins, with tight-fitting lids.

buff, cinnamon or yellow-ochre to as dark as buckthorn-brown or ochraceous tawny; irregular areas outlined by narrow black lines rather common. Sporophores are formed in some flasks, usually where the mycelium makes contact with the glass. The sporophores are much distorted by pressure against the glass and produce basidiospores in sufficient abundance as to cause a yellowish-green spore print. Wood decayed by *P. Andersonii* becomes very soft, white and spongy.

#### DISTRIBUTION

Ariz., *Quercus Gambelli* Nutt.; Ark., *Quercus* sp.; Calif., *Q. lobata* Née; Ind., *Q. rubra* L.; Kans., host not known; Md., *Quercus* sp. and *Salix nigra* Marshall; Mo., *Q. marilandica* Muench.; N. C., *Quercus* sp.; Ohio, *Populus* sp.; Ore., *Q. garryana* Doug.; Pa., *Carya* sp. and *Quercus* sp.; Texas, host not known; Va., *Quercus* sp.; and Wis., *Quercus* sp.

Cultures have been obtained from *Quercus* sp. from the following states: Calif., Md., Mo., Ohio and Va. From *Carya* sp.: Iowa and Ohio.

#### POLYPORUS GLOMERATUS

*Petri-dish cultures:* Growth very slow-forming in 7 days a mat 1-1.5 cm. or less in diameter. Mat usually closely appressed with a thin, whitish to yellowish covering over the inoculum, and a colorless zone of advancing growth; often with a distinct brown staled area under the mat. An occasional culture forms a white, cottony or woolly mound over the inoculum with no trace of staling.

In 14 days mat 2-4 cm. in diameter, usually appressed, thin, indeterminate in color about the margin and with a brown staled area under the center (FIG. 2, D); surface hyphae somewhat velvety or compacted over the inoculum; white or colorless at margin to primuline-yellow, olive-ochre or dark-olive-buff at center. An occasional culture fails to develop the brown staled area and becomes raised, thick, felty, white at margin to olive-buff and deep-olive-buff at center (FIG. 2, C).

Submerged hyphae either hyaline, staining deeply with eosin or yellowish, non-staining, 2-5  $\mu$  in diameter, without clamps; in

staled areas thick-walled, broken-up into irregular shapes often with short, connected, swollen cells (FIG. 1, *F*); fibrous hyphae brown, thick-walled, 1–5  $\mu$  in diameter; dark-brown, opaque, setal

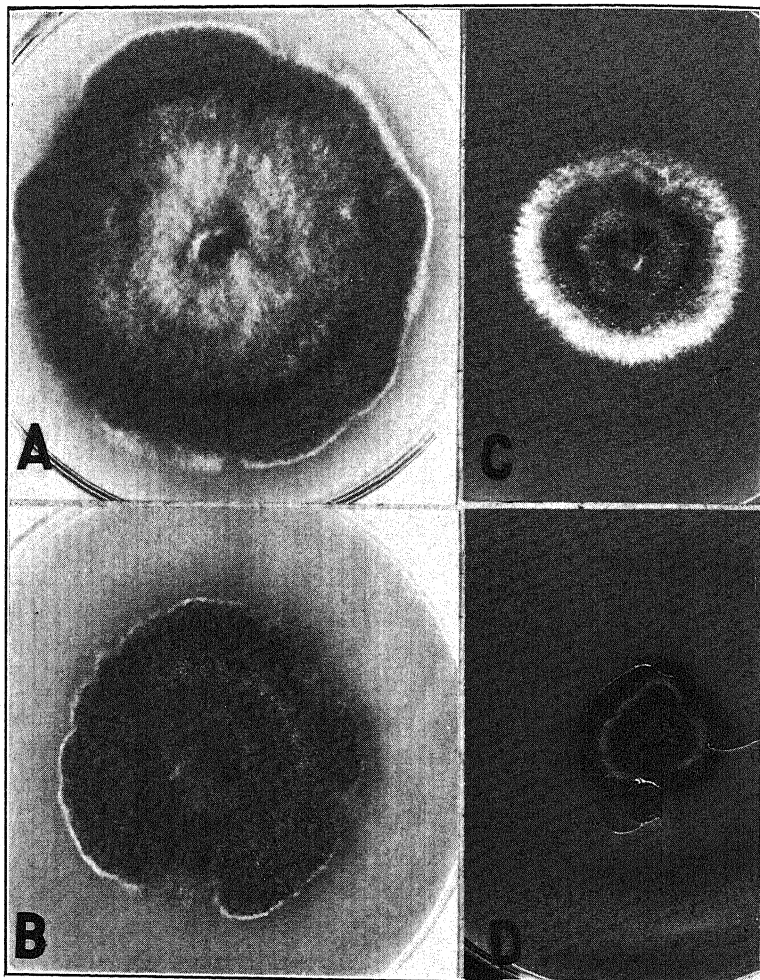


FIG. 2. *A* and *B*, petri-dish cultures age 14 days of *Poria Andersonii*. *C* and *D*, petri-dish cultures age 14 days of *Polyporus glomeratus*.

hyphae usually present in cultures 14 days old but sometimes lacking, 7–16  $\mu$  in diameter and 150–400  $\mu$  long (FIG. 1, *G*).

*Temperature relations:* Optimum temperature for growth approximately 25° C.

*Test tube cultures:* In 14 days appearance of different cultures rather variable, either slow-growing, appressed, with dark-brown staled areas under the mat and with scant white to olive-ochre thin cottony, or velvety, superficial growth; or raised, thick woolly on slant to cottony on agar cylinder and lacking the staled area under the mat; white at margin to buffy brown on slant with a trace of olive-ochre; setae appearing as radiating streaks against the glass, visible with the naked eye and very prominent under a lens.

In 28 days mat darker, from old-gold to yellow-ochre and buckthorn-brown usually with dark-brown staled area extending beyond the margins of growth.

*Flask cultures:* On hard maple blocks in wide mouth flasks, *P. glomeratus* forms a luxuriant cottony mycelium, much heavier and more robust than on malt agar. Small abortive sporophores form in from 7 to 10 months. The fungus makes little growth on oak heartwood but develops a moderately heavy mycelium on the sapwood. Sporophore formation takes place in 6-8 months with fairly large, well-formed fruiting bodies, producing yellowish-green spores in abundance, formed on the top or sides of the oak blocks. The oak sapwood is well decayed but the heartwood is only slightly attacked.

#### DISTRIBUTION

Cultures obtained from decay studies indicate that the fungus causes a trunk rot in living *Acer Saccharum* Marshall, and *A. rubrum* L. in Conn., Mass., Mich., Penn., W. Va., Va., and Wis. In addition, cultures have been obtained from a sporophore on beech collected in Mass.

#### CULTURAL DIFFERENCES

The mats formed by the two fungi, on malt agar, are entirely dissimilar as to general appearance. *P. Andersonii* is typically yellow at all ages, and is usually woolly or felty in texture. *P. glomeratus* commonly starts as a white mycelium about the inoculum becoming compacted, olive-buff. In addition the former grows 2 to 3 times as fast and has an optimum temperature of approximately 35° C. in contrast to an optimum of approximately 25° for *P. glomeratus*. In both species setal hyphae are formed

in culture, but those produced by *P. glomeratus* are usually larger, more opaque, typically from 7–16  $\mu$  in diameter, while those of *P. Andersonii* usually range from 5–8  $\mu$ . In addition, the latter produces short bulbous setae on the mat surface, especially in staled areas. This form is rarely found in *P. glomeratus* cultures.

#### ECONOMIC IMPORTANCE

*Poria Andersonii* is one of the fungi commonly isolated from trunk decay of living oak trees throughout the middle western states. It usually enters through branch stubs but it may also enter through fire-scars or other injuries. It causes a white decay similar to that caused by *Fomes Everhartii*.

*Polyporus glomeratus* causes a white to light-brown spongy heart rot of maples and is common (especially on sugar maple) in some areas in the Lake States.<sup>6</sup>

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## NEW SPECIES OF UREDINALES<sup>1</sup>

GEORGE B. CUMMINS

(WITH 6 FIGURES)

### *Puccinia incallida* Cum. sp. nov. (FIG. 2)

Pycniis epiphyllis, globosis, 90–120  $\mu$  diam., paucis. Aeciis epiphyllis, uredinoidis, minutis, flavidis, aggregatis in maculis flavis 0.5–2.0 mm. diam.; aeciosporis ellipsoideis vel obovoideis, 23–30  $\times$  29–40  $\mu$ ; membrana 2–2.5  $\mu$  cr., cinnamomeo- vel aureo-brunnea, valide aculeata (3  $\mu$ ), poris germ. obscuris (3 aequatorialibus?). Urediis ignotis. Teliis ignotis; teliosporis in aeciis ellipsoideis, utrinque rotundatis, ad septum constrictis, 19–23  $\times$  40–55  $\mu$ ; membrana aequaliter 1–1.5  $\mu$  cr., hyalina, levi; pedicellis hyalinis, brevibus.

On *Gouania longipetala*, between Suhum and Apedwa, Gold Coast, Africa, July 28, 1937, *F. C. Deighton* CB846. Type in the Arthur Herbarium, Purdue University Agricultural Experiment Station and the Herbarium of the Imperial Mycological Institute.

*Puccinia incallida* appears to be closely related to *P. paraensis* Diet. from Brazil but differs in lacking paraphyses and in having larger teliospores.

### *Puccinia subtegulanea* Cum. sp. nov. (FIG. 1)

Pycniis et aeciis ignotis. Urediis hypophyllis, cinnamomeo-brunneis, aggregatis vel confluentibus, ellipticis vel linearibus, 0.5–2 mm. longis epidermide bullata dein longitudinaliter fissa diu tectis; urediosporis ellipsoideis vel obovoideis, 11–15  $\times$  15–19  $\mu$ ; membrana 1  $\mu$  cr., cinnamomeo-brunnea, dense et minute echinulata, poris germ. 2, aequatorialibus. Teliis hypophyllis, subepidermalibus, dense aggregatis, atris, multiloculatis, indehiscentibus, soris individuis minutis, paraphysibus numerosis coalitis; teliosporae variabiles, oblongae vel clavatae, ad apicem obtusae, rotundatae vel rostratae, ad basim attenuatae, medio non vel leniter constrictae, 10–16  $\times$  28–40  $\mu$ ; membrana 1  $\mu$  cr., ad apicem 3–6  $\mu$ , castaneo-brunnea, levi; pedicellis brevibus, fulvis.

On *Mariscus umbellatus*, Akwadum, Gold Coast, Africa, August 17, 1937, *F. C. Deighton* CB910. Type deposited in the Arthur

<sup>1</sup> Contribution from the Botany Department, Purdue University Agricultural Experiment Station, Lafayette, Indiana.

Herbarium, Purdue University Agricultural Experiment Station and the Herbarium of the Imperial Mycological Institute.

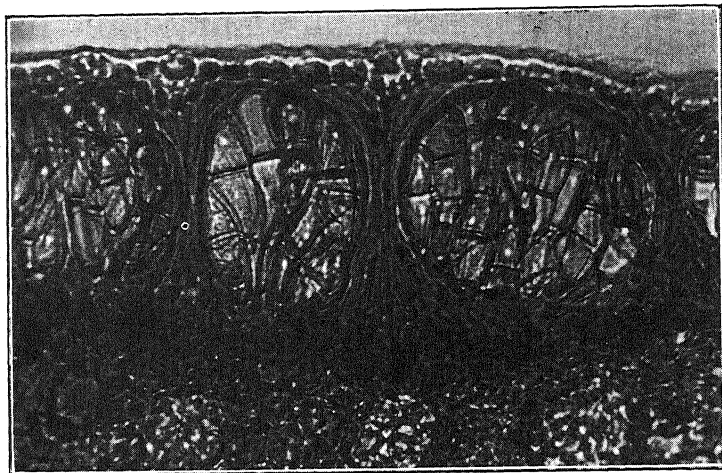


FIG. 1. *Puccinia subtegulanea*, showing loculate, indehiscent telia.  $\times 500$ .

This species is similar in general to the group of species which has two germ pores in the urediospores and indehiscent loculate telia, but has smaller spores than any previously described.

### *Puccinia Thelypodii* Cum. sp. nov. (FIG. 3)

Pycniis globosis, 90–130  $\mu$  diam., sparsis. Aeciis plerumque per totam foliorum superficiem inferiorem aequè distributis vel rarius aggregatis, margine recurvato; cellulis peridii 16–19  $\times$  22–29  $\mu$ , pariete interiore verrucoso 2–3  $\mu$  cr., exteriore striato 5–7  $\mu$  cr.; aeciosporis ellipsoideis vel globosis 13–16  $\times$  16–19  $\mu$ ; membrana hyalina 1  $\mu$  cr., minuteque verrucosa. Urediiis sparsis, rotundatis, 0.3–1.0 mm. diam., hypophyllis vel rarius epiphyllis, pulverulentis, cinnamomeo-brunneis; urediosporis late ellipsoideis vel globosis, 18–20  $\times$  20–26  $\mu$ ; membrana 1.5–2  $\mu$  cr., cinnamomeo-brunnea, dense et minuteque echinulata, poris germ. 2 aequatorialibus. Teliis cauliculis et fructicolis, ellipsoideis vel rotundatis, 0.3–2.0 mm. longis, pulvinatis, atrobunneis; teliosporae clavatae, oblongae vel ellipsoideae, ad apicem rotundatae, truncatae vel attenuatae, ad basim attenuatae, medio constrictae, 19–24  $\times$  39–58  $\mu$ ; membrana castaneo-brunnea, 1.5–2.5  $\mu$  cr., ad apicem 5–10  $\mu$  cr., levi; pedicello hyalino vel apice flavidulo, persistenti, 6–10  $\times$  50–90  $\mu$ .

On *Thelypodium lasiophyllum*, Soboba Hot Springs, Riverside County, California, February 1938, H. E. Parks 6154. Type in

the Arthur Herbarium, Purdue University Agricultural Experiment Station.

When Mr. Parks sent this specimen he wrote that he believed telia on the old plants were inoculating the seedlings which bore the aecia and uredia. His suggestion was verified by cultures using plants raised from seed in the greenhouse at Lafayette, Indiana, and subjected to inoculation by germinating teliospores on the old stems sent with the original collection. Inoculations made April 21 and May 6 produced pycnia May 1 and May 16 and aecia May 5 and May 22, respectively. The species is thus autoecious and macrocyclic.

***Uropyxis reticulata* Cumm. sp. nov. (FIG. 4)**

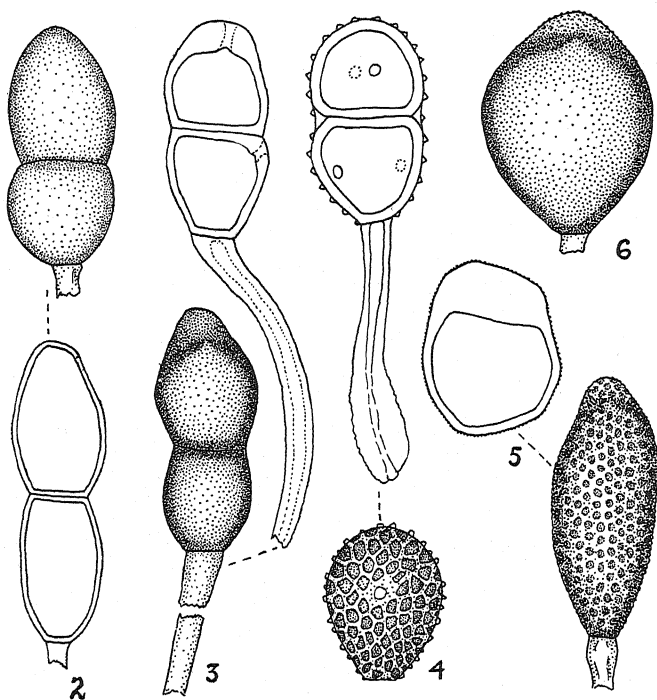
Pycniis et aeciis ignotis. Urediis subepidermicis hypophyllis, sparsis, minutis, 0.1–0.3 mm. diam. vel ramicolis in incrassationibus elongatis fusiformibus copiose ortis, brunneis; urediosporae obovoideae,  $16\text{--}22 \times 23\text{--}27 \mu$ ; membrana  $2 \mu$  cr., cinnamomeo-brunnea, reticulata, poris germ. 2, aequatorialibus. Teliis conformibus; teliosporae ellipsoideae vel oblongae, utrinque rotundatae, medio leniter constrictae,  $18\text{--}23 \times 31\text{--}40 \mu$ ; membrana  $2.5\text{--}3 \mu$  cr., cinnamomeo- vel castaneo-brunnea, verrucosa, quaque cellula poris binis mediis praedita; pedicello persistenti, sporam aequante, deorsum lenissime incrassato.

On *Bignonia Unguis-cati*, La Plata, Argentina, February 1937, Juan C. Lindquist (type); La Plata, Argentina, May 1920, C. Spegazzini. Type in the Arthur Herbarium, Purdue University Agricultural Experiment Station and the Museo de La Plata, La Plata, Argentina.

Spegazzini (Rev. Argent. Bot. 1: 108. 1925) first reported this rust as *Puccinia Bignoniacearum* Speg., an entirely different species which belongs in the genus *Prospodium*. His specimen, kindly loaned to me by Dr. Lindquist, consists of foliicolous sori, while Lindquist's later collection consists of the ramicolous form and is here taken as the type.

The species is unique in developing urediospores with reticulately sculptured walls and has only two equatorial pores, while *Uropyxis* is characterized by urediospores having several scattered pores. Although lamination of the walls of the teliospores is observable only at the septum the presence of two pores in each cell clearly indicates the genus *Uropyxis*.





FIGS. 2-6. 2, teliospores of *Puccinia incallida*; 3, teliospores of *Puccinia Thelypodii*; 4, one teliospore and one urediospore of *Uropyxis reticulata*; 5, one aeciospore and one teliospore of *Uromyces evastigatus*; 6, one teliospore of *Uromyces dilucidus*. (All figures from type specimens.  $\times 650$ .)

*Uropyxis Rickiana* Magn., also on some bignoniaceous host, likewise causes hypertrophy and has similar teliospores. I have not seen this species but since no urediospores were described it seems advisable to keep *U. reticulata* separate.

***Uromyces dilucidus* Cumml. sp. nov. (FIG. 6)**

Pycniis, aeciis et urediis ignotis. Teliis amphigenis,  $0.2-0.5 \times 0.5-1.5$  mm., sparsis vel aggregatis, pulverulentis, castaneo-brunneis; teliosporis globoso-ellipsoideis vel ovatis, apice rotundatis, papilla subhyalina verruculosa usque  $5 \mu$  alta instructis,  $29-33 \times 32-44 \mu$ ; membrana cinnamomeo-vel castaneo-brunnea,  $2-3 \mu$  cr., levi; pedicello hyalino, brevi, deciduo.

On *Sisyrinchium striatum*, Tunuyán, Mendoza, Argentina, March 8, 1933, Ruiz Leal 1273. Type in the Arthur Herbarium,

Purdue University Agricultural Experiment Station and the Museo de La Plata, La Plata, Argentina.

Although only telia are present in this collection it is not probable that the species is microcyclic. *Uromyces dilucidus* is distinctive because of the large teliospores.

***Uromyces evastigatus* Cum. sp. nov. (FIG. 5)**

(*Pucciniola Urbaniana* Arth. N. Am. Flora 7:795. 1926. Not *Uromyces Urbanianus* P. Henn. 1897.)

Pycnia paucis amphigenis, profunde immersis,  $120-150 \times 180-250 \mu$ , maculis incrassatulis usque 1.5 cm. diam. occupantibus. Aeciis cupulatis, gregaris, inter pycnia sparsis, plus minusve profunde immersis, 0.3-0.4 mm. diam., margine lacerato; cellulis peridii  $18-27 \times 35-55 \mu$ , pariete interiore rugoso  $2-2.5 \mu$  cr., exteriore striato  $3-6 \mu$  cr.; aeciosporis oblongis, ellipsoideis vel angulato-globosis  $19-27 \times 29-41 \mu$ ; membrana  $1.5-2.5 \mu$  cr., ad apicem  $5-12 \mu$ , hyalina vel flavida, minuteque verruculosa. Urediis nullis. Teliis amphigenis, aggregatis, 1-2 mm. diam., pulverulentis, castaneo-brunneis; teliosporis oblongis vel ellipsoideis, apice rotundatis vel attenuatis,  $20-25 \times 39-53 \mu$ ; membrana castaneo-brunnea  $2-3 \mu$  cr., ad apicem  $6-9 \mu$ , reticulata ( $1-1.5 \mu$  diam.); pedicello brevi, hyalino.

On *Phthirusa pyrifolia*, vicinity of San Salvador, El Salvador, March 30-April 24, 1922, Paul C. Standley 23106 (type); vicinity of Tonacatepeque, Dept. San Salvador, El Salvador, December 30, 31, 1921, Paul C. Standley 19473. Type in the Arthur Herbarium, Purdue University Agricultural Experiment Station.

*Uromyces evastigatus* differs from *U. Urbanianus* P. Henn., to which Arthur (*l.c.*) originally assigned the above collection but under the now abandoned genus *Pucciniola*, in having larger and more coarsely sculptured teliospores.

During this study it was found that in several species described as having verrucose teliospores the sculpture is actually reticulate, although very finely so. The following key, based upon this study, gives differential characters for the species of *Uromyces* on Loranthaceae:

Teliospores longitudinally ridged.

Teliospore-pedicel long, rugosely inflated. .... *U. ornatipes* Arth.

Teliospore-pedicel short, fragile.

Teliospores large,  $38-50 \mu$  long. .... *U. euphlebius* Sydow.

Teliospores smaller,  $32-37 \mu$  long. .... *U. socius* A. & H.

Teliospores reticulate, sometimes striately so.

Species macrocyclic.

Urediospores echinulate. .... *U. Loranthi* J. & H.

Urediospores longitudinally ridged. .... *U. Phirusae* Mayor.

Species demicyclic.

Reticulation obscure; pits  $0.5-0.8\ \mu$  diam.

Teliospores ellipsoid,  $18-23 \times 29-35\ \mu$ . *U. circumscriptus* Neger.

Teliospores oblong-ellipsoid,  $15-23 \times 33-43\ \mu$ .

*U. Urbanianus* P. Henn.

Reticulation obvious; pits  $1-1.5\ \mu$  diam.

Teliospores oblong-ellipsoid,  $20-25 \times 39-53\ \mu$ .

*U. evastigatus* Cumm.

The specimens of *Puccinia incallida* and *P. subtegulanea* were received from Dr. G. R. Bisby, the Imperial Mycological Institute, Kew, England, of *Uropyxis reticulata* and *Uromyces dilucidus* from Dr. Juan C. Lindquist, Museo de La Plata, La Plata, Argentina, and of *Puccinia Thelypodii* from Mr. H. E. Parks, Trinidad, California.

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## THE GENERA, SKIERKA AND CTENODERMA

E. B. MAINS<sup>1</sup>

(WITH 14 FIGURES)

The genus *Skierka* was described by Raciborski (11) in 1900 and was based on the species *Skierka Canarii*. The teliospores were described as one-celled, fusoid, having acuminate apices, without pedicels, and issuing from the telium in a *Cronartium*-like column. Four other species have been described, *S. congoensis* from Africa by P. Hennings (9) in 1907, *S. Agallochoa* from Java by Raciborski (12) in 1909, *S. Holzwayi* from Central America by Arthur (1) in 1918 and *S. robusta* from Africa by Doidge in 1926.

During the summer of 1936, the writer collected a rust on *Cupania belizensis* in the El Cayo District of British Honduras.<sup>2</sup> This proved to be the telial stage of a species of *Skierka*. Species of *Skierka* have not been reported on species of *Cupania*. However, *Ctenoderma cristata* has been reported on several species of *Cupania* from Tropical America. A study of collections<sup>3</sup> of this rust has resulted in an interesting discovery. The genus *Ctenoderma* was described by the Sydows (17) in 1919, *Ctenoderma cristata* (Speg.) Sydow (*Uredo cristata* Speg.) being cited as the type species. The Sydows concluded that the spores which had been described as urediniospores were teliospores. These were described as one-celled, the wall of two layers, the outer gela-

<sup>1</sup> Papers of the Department of Botany and Herbarium of the University of Michigan.

<sup>2</sup> This expedition was part of a study of the biology of the Maya area, a cooperative study between the University of Michigan and the Carnegie Institution of Washington and was supported by funds from the Horace H. Rackham School of Graduate Study.

<sup>3</sup> Through the kindness of Dr. George B. Cummins the specimens of species of *Skierka* and *Ctenoderma* in the Arthur Herbarium have been available for study. The writer is also indebted to the Director of the Royal Botanical Gardens Kew for loans of types of *Ctenoderma Petchii* and *C. Diploglottidis*.

tinous and thickening above. The species *Ctenoderma cristata* has this spore stage associated with pycnia in small hypertrophied areas. Among the collections available for this study two were discovered which bore abundant scattered telia, typical of *Skierka*, associated with this stage. From these specimens it seems evident that the stage described as telial for *Ctenoderma* is in reality the uredinial. A comparative study of species of *Ctenoderma* with species of *Skierka* has resulted in the conclusion that the former should be included in the genus *Skierka*.

Those species of *Skierka* for which telia are known show considerable similarity in the telial stages (FIG. 9-14), all having fusoid, thin-walled spores which adhere and are forced out of the narrow opening of the telium in columns. There is a greater variation in the uredinial stage. However, a certain similarity occurs throughout the species. They all show more or less lateral thickening of the wall (FIG. 1-8), forming two opposite lateral ridges or plates. This thickening surrounds the spore longitudinally except for the hilum. In *Skierka congouensis* (FIG. 1) it is inconspicuous, the wall of the spore gradually increasing in thickness from 1-1.5  $\mu$  on the two faces to 4-6  $\mu$  in the lateral longitudinal ridges, the spores therefore being only slightly broader and the wall thicker with the ridges in optical plane than when in surface view. The echinulations of the spore are in longitudinal rows, the rows on the edges of the ridges not differing conspicuously from those on the face. In *Skierka Canarii* (FIG. 3) the wall of the urediniospore shows two layers. The outer hyaline wall is thickened to form a wing-like ridge surrounding the spore longitudinally except for the hilum. The echinulations are arranged in longitudinal rows. Those on the edges of the wings are modified to form a fringe of close set, curving teeth. In *Ctenoderma cristata* (FIG. 4), the outer wall of the urediniospores swells to form a thick plate longitudinally surrounding the spore except for the hilum. With the thickening seen in optical section, the spores are much wider than when in surface view. The two edges of each of the lateral wings are crenate or serrate. The urediniospores of *Ctenoderma Diploglottidis* (FIG. 5) resemble those of *C. cristata*. In *Skierka Holwayi* (FIG. 7) the thickening of the wall reaches its maximum development. The hyaline outer

wall swells to form a very broad wing-like plate surrounding the spore longitudinally except for the hilum. The spore is therefore, considerably wider with the plate in the optical plane than when on edge. The edges of the plate are irregularly crenate. *Ctenoderma Petchii* (FIG. 6) has urediniospores which approach those of *S. Holwayi*.

The relationship of the genus *Skierka* to other genera of the rusts is uncertain. From herbarium specimens it is very difficult to determine accurately the manner of development of the teliospores. The teliospores more or less adhere laterally and tend to form long threads or columns. In *Skierka Holwayi* the adherence is very pronounced and long columns are produced which do not break up easily. In the other species it is less pronounced and the threads or columns may disintegrate in water if some pressure is applied. The teliospores are not catenulate. As Raciborski (11) has pointed out, the younger develop between the older, adhering to them and pushing them upward. The teliospores are borne on small globoid cells and at maturity usually separate from them. When the spores are removed from the telium with a scalpel an occasional spore is found with torn remnants of the basal cell adhering. It is possible that such spores are immature and their forcible removal may have ruptured the thin-walled basal cells. There is no well differentiated pedicel and the teliospores have usually been described as sessile. The Sydows (20) and Dietel (7) emphasize the position of the uredinia and telia stating that they develop beneath stomata. Although this may be true it is not very evident. The sori are deep-seated. They remain covered by the epidermis and in some instances by cells beneath the epidermis, usually there is a layer of compacted hyphae lining the overarching epidermis. The sori finally open by a pore or small slit.

Although the teliospores have usually been considered sessile, *Skierka* has been placed in the Pucciniaceae by most authors. Raciborski (11) believed that it was most closely related to *Hamaspora*. Other than in the shape of the teliospores there is very little similarity, *Hamaspora* having free, 2-4-celled teliospores with very long pedicels. The Sydows (20) have placed *Skierka* in the Pucciniaceae stating that in spite of the sessile, adhering teliospores,

it is a *Uromyces*-like rust with fusoid teliospores. However, they were uncertain concerning its position in this family.

Arthur (3) has proposed a subfamily Skierkatae of the Aecidiaceae (Pucciniaceae) in which he included *Skierka*, *Ctenoderma*, *Sphenospora* and *Chaconia*. In *Sphenospora*, the teliospores are free from each other, two-celled with vertical septa and remain attached to well-developed pedicels. In *Chaconia* the teliospores are borne in clusters on a well-developed basal cell and are otherwise free from each other. There are a number of clusters in a telium and these also are free from each other. There seems to be very little evidence of a close relationship of these two genera to *Skierka*.

Dietel (8) has placed *Skierka* by itself in the tribe Skierkeae of the Pucciniaceae. He (7) states that the development of sori beneath stomata, the adherence of spores forming sporehorns, the creasing of the urediniospores, and the colorless condition of the teliospores are characters found in *Uredinopsis* and therefore concludes that *Skierka* must belong to the oldest group of the Pucciniaceae. Because the members of the tribe Hemileieae of the Pucciniaceae develop their sori in relation to the stomata of their hosts, he would place the tribe Skierkeae near the Hemileieae. Also he suggests that *Skierka* may not be far from the genus *Spirechina*. The development of sporehorns in *Skierka* is most pronounced in the telia and is found in the uredinia only in *S. Holwayi* and there to a limited extent. The sporehorns of *Uredinopsis* are limited to the uredinia. The telial stage of *Skierka* is very different from that of *Uredinopsis*. It seems doubtful whether the suggested similarities to *Uredinopsis* necessarily indicate a position near the beginning of the Pucciniaceae. The relationship to the Hemileieae is also not evident. In the species of that tribe as recognized by Dietel, the spores are pedicellate, the pedicels projecting through the stomata bearing spores outside the host. In *Skierka* the spores develop within the host in deep seated sori, and they are forced out through small openings in the epidermis by the development of younger spores. Also the relationship to *Spirechina* is not very close since in that genus the teliospores are borne on well developed pedicels and are free from each other. If *Skierka* belongs in the Pucciniaceae it would seem to be more

closely related to *Chrysocelis* and *Bitzea* which have sessile, colorless, thin-walled teliospores. The teliospores of *Chrysocelis* and *Bitzea*, however, remain attached to the basal cells and are otherwise free from each other.

The possibility that *Skierka* may belong in the Melampsoraceae should not be disregarded. Apparently only Koorders (10) has placed it in this family and he does not discuss his reasons for so doing. The absence of pedicels and lateral adherence of the teliospores have been considered the principal differentiating characters of the Melampsoraceae. The external resemblance of the telia of *Skierka* to those of *Cronartium* has been noted but has been considered a superficial similarity. Apparently one of the principal reasons for excluding *Skierka* from this family is the non-catenulate arrangement of the teliospores. However, *Phakopsora* which has been placed by Dietel (8) in the Cronartieae next to *Cronartium* has telia in which the spores are not catenulate, the younger developing between the older. This genus forms compact crusts of brown-walled spores not columns of hyaline spores.

It seems evident that *Skierka* represents a distinct line of development and should be placed in a tribe Skierkeae by itself. With the present two family separation in the Uredinales, the information now available concerning this genus would appear to point as much toward a position near the Cronartieae in the Melampsoraceae as toward the Pucciniaceae. It is evident that a realignment of the genera of the Uredinales is necessary and it is probable that then *Skierka* will fall in a family intermediate between the Melampsoraceae and the Pucciniaceae.

SKIERKA Racib. Parasitische Algen und Pilze Javas II p. 30. 1900.

*Ctenoderma* Sydow, Ann. Myc. 17: 102. 1920.

Pycnia subepidermal, sometimes deep-seated in hypertrophied areas; uredinia subepidermal, deep-seated opening by a pore, urediniospores with the wall thickened into two opposite longitudinal ridges or bands, the thickenings often swelling considerably in water; telia subepidermal, deep-seated, opening by a pore; teliospores fusoid, the wall colorless, often showing two layers, the outer separating from the inner, the younger teliospores developing between the older, adhering to them and the spore mass usually pushing out of the telium as a thread or column.



TYPE SPECIES, *Skierka Canarii* Racib.

SKIERKA CONGONENSIS P. Henin. Ann. Musee Congo Bot. V. 2: 90. 1900.

Uredinia hypophyllous, subepidermal, in small groups, pulverulent; urediniospores narrowly ellipsoid or ellipsoid-fusoid,  $12-16 \times 24-36 \mu$ , the wall  $1.5 \mu$  thick, at the apex up to  $5 \mu$  and in two lateral longitudinal ridges up to  $4 \mu$ , a row of coarse-echinulations on the edge of the ridges, elsewhere moderately echinulate in longitudinal lines, the pores obscure (FIG. 1).

Telia hypophyllous, subepidermal, in small groups, covered by the epidermis except for a small slit or pore, the teliospores adhering and forced out in very long, delicate white threads; teliospores fusoid,  $7-10 \times 60-80 \mu$ , very acuminate at the apex, truncate at the base, the wall thin,  $1 \mu$ , smooth, hyaline, separating into two layers (FIG. 9).

SPECIMENS STUDIED:

*Alchornea cordifolia* Muell. Njala, Sierra Leone, Dec. 13, 1935, F. C. Deighton, 930.

*Macaranga* sp. Kisautu, Congo, Feb. 23, 1907, H. Vanderyst.

***Skierka philippinensis* sp. nov.**

Urediniis hypophyllis, subepidermalibus, diu epidermide tectis, sparsis, 0.2-0.5 mm. diam.; urediniosporis ellipsoideis vel ellipsoideo-fusoideis,  $12-16 \times 28-54 \mu$ , membranis  $1-1.5 \mu$  crassis, lateraliter  $4-6 \mu$ , formantibus juga, moderate echinulatis, poris indistinctis; teliis hypophyllis, subepidermalibus, diu epidermide tectis, sparsis; teliosporis coalitis formantibus columellas, fusoideis,  $11-19 \times 64-110 \mu$ , membranis hyalinis,  $1.5-2.5 \mu$  crassis.

Specimen typicum in foliis *Canarii luzonici*, Bambong, Nueva Viscaya, Luzon, Philippines, Jan. 1924, Clemens, 1720.

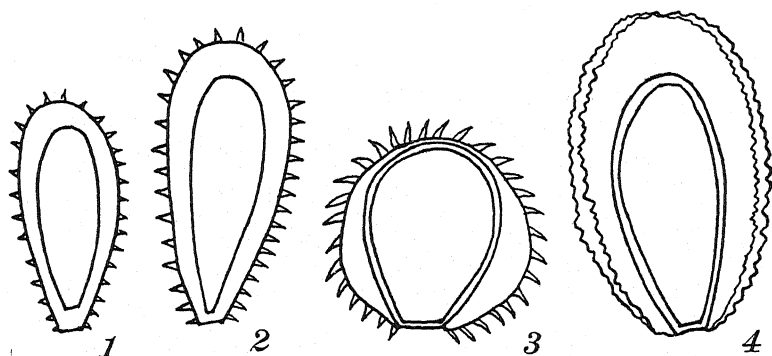
Uredinia hypophyllous, scattered, 0.2-0.5 mm. across, subepidermal, covered by the epidermis and a thin layer of compacted hyphae except for a small pore or slit, pulverulent; urediniospores ellipsoid or ellipsoid-fusoid  $12-16 \times 28-54 \mu$ , the wall  $1-1.5 \mu$ , thickening laterally  $4-6 \mu$  in a band extending longitudinally around the spore except for the hilum, moderately echinulate in longitudinal lines, pores obscure (FIG. 2).

Telia hypophyllous, scattered 0.2-0.5 mm. across, subepidermal, similar to the uredinia, the teliospores adhering and forced out in irregular loose columns; teliospores fusoid,  $11-19 \times 64-110 \mu$ , the wall smooth, hyaline,  $1.5-2.5 \mu$  thick, the outer layer often separating from the inner, the apex long acuminate, the base truncate (FIG. 10).

## SPECIMENS EXAMINED:

*Canarium luzonicum* A. Gray, Bambang, Nueva Viscaya, Luzon, Philippine Islands, Jan. 1924, Clemens, 1720, type (deposited in the Arthur Herbarium, Purdue University and the Herbarium of the University of Michigan).

*Canarium* sp. Pangasinan, Luzon, Philippine Islands, Feb. 1-14, 1925, Clemens, 5912; Quemburg Mission, Morobe, New Guinea, Dec. 11, 1935, Clemens, 1327; March 23, 1936, Clemens, 2160.



FIGS. 1-4. Urediniospores of species of *Skierka* with lateral thickenings of the wall in the optical plane,  $\times 600$ ; 1, *Skierka congonensis*; 2, *S. philippinensis*; 3, *S. Canarii*; 4, *S. cristata*.

Collections of this species have been identified as *Skierka Canarii*. The latter has smaller urediniospores and teliospores and the urediniospores have two narrow lateral wings edged with a fringe of fine teeth-like echinulations. The echinulations of *Skierka philippinensis* are arranged longitudinally in rows, the rows on the thickened band sometimes being somewhat closer and larger. The walls of the teliospores frequently show two layers, the outer separating from the inner.

SKIERKA CANARII Racib. Parasitische Algen und Pilze Javas 2: 30. 1900.

Uredinia minute, hypophyllous, scattered or in small groups, subepidermal, covered by the epidermis except for a small pore, pulverulent; urediniospores as bounded by the inner wall obvoid,  $14-16 \times 24-30 \mu$ , the inner wall hyaline or yellowish, uniform in thickness,  $1-1.5 \mu$ , the outer  $1-1.5 \mu$ , thickening into two opposite

longitudinal wings  $2.5-6\ \mu$  wide, the edges provided with a fringe of curving teeth-like projections, the remainder of the spore coarsely echinulate in longitudinal lines, with the wings in the optical plane circular in outline,  $24-38 \times 24-30\ \mu$  (FIG. 3).

Telia minute, hypophyllous, scattered or in small groups, sub-epidermal, covered by the overarching epidermis, the teliospores adhering and forced out through a small pore as a short column; teliospores fusoid,  $8-12 \times 54-80\ \mu$ , the wall smooth, hyaline, then  $1\ \mu$  or less, the apex acuminate, solid,  $14-40\ \mu$ , the base truncate (FIG. 11).

SPECIMENS EXAMINED:

*Canarium commune* L., Buitenzorg, Java, 1900, M. Raciborski, Sydow Ured. 2289.

*Canarium moluccanum* Blume, Purmaredjo, Java, Aug. 1905, S. H. Koorders.

*Canarium* sp. Sattelberg, Morobe, New Guinea, March 3, 1936, Clemens, 1924.

Koorders (10) has also reported this species from Java. The specimens reported by Arthur and Cummins (4) prove to be the preceding species. The Sydows (16) and Sydow and Petrak (18, 19) have reported *S. Canarii* on *Canarium villosum* for the Philippines. It is probable that some at least of the collections are *S. philippinensis*.

The lateral wings of the urediniospores are best seen when in the optical plane. They are lateral enlargements of the outer hyaline wall usually vertical, sometimes somewhat oblique. The fringe of slender, curving teeth on their margins is one of the distinguishing marks of the species. This and the small urediniospores separate this species from *S. philippinensis*.

The teliospores adhere somewhat and are forced through the small opening of the telium as a column. They are not catenulate but as Raciborski has pointed out, the younger spores are forced up between the older.

**Skierka cristata** (Speg.) comb. nov.

*Uredo cristata* Speg. Anal. Soc. Ci. Argent. 17: 119. 1884.

*Uromyces Cupaniae* Arth. & Johnston, Mem. Torrey Club. 17: 131. 1918.

*Ctenoderma cristatum* Sydow, Ann. Myc. 17: 103. 1920.

Pycnia amphigenous, grouped in hypertrophied areas 2–5 mm. across, subepidermal, oblate-spheroid, 100–200  $\mu$  wide, 80–100  $\mu$  thick, ostiolar filaments present.

Uredinia mostly hypophyllous, deep seated in the hypertrophied tissue, covered by a thin layer of compacted hyphae beneath the epidermis, opening by a small pore, pulverulent; urediniospores as bounded by the inner wall narrowly obovoid or fusoid, 16–20  $\times$  30–40  $\mu$ , the inner wall yellowish, uniform in thickness, 1.5–2.5  $\mu$ , the outer wall hyaline, swelling to form a longitudinal plate, the wings reaching 10–15  $\mu$  in width over the upper portion of the spore, with the plate in the optical plane the spores obovate or fusiform in outline, 22–30  $\times$  40–55  $\mu$ , coarsely and sparsely echinulate in the upper portion, crenate or serrate in lines on the edges of the lateral wings, the pores obscure, the apices rounded or acute (FIG. 4).

Telia hypophyllous, scattered or in small groups, similar to the uredinia, the spores adhering and often forced out in long, delicate, white threads; teliospores fusoid, 10–15  $\times$  60–96  $\mu$ , the wall thin, 1  $\mu$ , of two layers, the outer finally separating from the inner, the apex acuminate, the base truncate (FIG. 12).

#### SPECIMENS EXAMINED:

*Cupania americana* L. Maravale Valley, Port-of-Spain, Trinidad, May 14, 1913, R. Thaxter 40, Rel. Farl. 673, III.

*Cupania belizensis* Standl., Benque Viejo, El Cayo, British Honduras, July 17, 1936, E. B. Mains, 3524, III.

*Cupania macrophylla* A. Rich. San Antonio de las Baños, Cuba, June 11, 1916, J. R. Johnston, 779, O II III; Taco Taco, Cuba, Sept. 17, 1916, J. R. Johnston, 876, O II; Santiago de las Vegas, Cuba, Dec. 3, 1916, J. R. Johnston, 927, O II.

*Cupania* sp. Santiago de las Vegas, Cuba, June 6, 1905, C. F. Baker, 88, O II III; Paraguay, Jan. 1882, Speg. F. Guar. 131.

Arthur and Johnston (5) decided that the urediniospores of this rust were teliospores and placed it in the genus *Uromyces* under the name *Uromyces Cupaniae* since the name *Uromyces cristata* was preoccupied. They noted a similarity to *Skierka*. The Sydows (17) also concluded that the urediniospores were teliospores and proposed the genus *Ctenoderma* with this as the type species. However, teliospores typical of the genus *Skierka* occur abundantly on two specimens (Johnston, 779 and Baker, 88) closely associated with the sori interpreted as telia by Arthur and Johnston and the

Sydows. It is evident that the latter are uredinia. In addition to the specimen from British Honduras, Thaxter's collection (Rel. Farl. 673) from Trinidad bears telia (Arthur, 2). As in other species of *Skierka* the walls of the urediniospores are laterally thickened, more so than in the previous species. The outer wall swells in water. This takes place unequally and forms a thick plate surrounding the spore longitudinally except for the hilum. The edges of the plate are crenate or serrate giving the spore its cristate appearance. The teliospores are very similar to those of other species of *Skierka*. They adhere and are forced through the narrow openings of the telia as long delicate white threads. The wall of the teliospore separates into two layers. The long acuminate apex of the teliospore is solid for most of its length. When the teliospore germinates the wall breaks and the solid apex is pushed off.

***Skierka Diploglottidis* (Cooke & Masee) comb. nov.**

*Uromyces Diploglottidis* Cooke & Masee, Grevillea 17: 55. 1889.

*Ctenoderma Diploglottidis* Sydow, Ann. Myc. 20: 55. 1922.

Uredinia mostly epiphyllous, in green islands, subepidermal, covered by the epidermis and a thick ( $10-20\ \mu$ ) compacted layer of hyphae except for a small pore or slit; urediniospores as bounded by the inner wall, oblong-fusoid,  $12-16 \times 32-42\ \mu$ , the inner wall yellowish,  $1.5-3\ \mu$  thick, the outer hyaline, thickened to form two opposite longitudinal lateral plates, with the plates in the optical plane, the spores elliptic-fusiform in outline,  $22-28 \times 40-60\ \mu$ , the apices acute, the edges of the plates crenate (FIG. 5).

Telia similar to the uredinia; teliospores in the specimen examined collapsed, apparently fusoid,  $15-18 \times 70-90\ \mu$ , the wall colorless,  $1.5\ \mu$ , the apex acute.

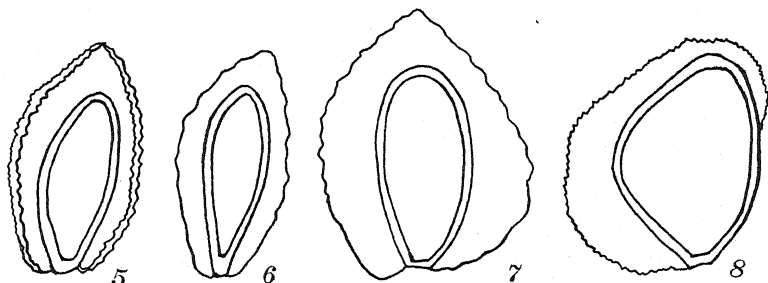
**SPECIMEN EXAMINED:**

*Diploglottis* sp. Brisbane, Queensland, Australia, Bailey, 626, type.

Cooke (6) described the urediniospores as teliospores. Sydow (13) studied the specimen in the Kew Herbarium and decided that the rust was a species of *Ctenoderma*. He gives the host as

*Diploglottis Cunninghamii*. Sydow (15) has reported another collection from Australia.

The type specimen apparently has teliospores characteristic of *Skierka*. They are collapsed and are difficult to study. The



FIGS. 5-8. Urediniospores of species of *Skierka* and *Ctenoderma* with lateral thickenings of the wall in the optical plane,  $\times 600$ : 5, *S. Diploglottidis*; 6, *S. Petchii*; 7, *S. Holwayi*; 8, *Ctenoderma Toddaliae*.

spores which have been described as teliospores are apparently urediniospores similar to those of other species of *Skierka* specially *S. cristata*, having somewhat similar lateral thickenings of the wall.

***Skierka Petchii* (Sydow) comb. nov.**

*Ctenoderma Petchii* Sydow, Ann. Myc. 21: 342. 1923.

Uredinia amphigenous, crowded in reddish-brown spots, sub-epidermal, covered by the epidermis except for a small pore or slit; urediniospores narrowly ellipsoid as bounded by the inner wall,  $8-12 \times 24-50 \mu$ , the inner wall yellowish,  $1.5-2 \mu$  thick, the outer wall hyaline, thickened to form two lateral longitudinal wings, with the wings in the optical plane, the urediniospores fusiform in outline,  $18-20 \times 39-60 \mu$ , the apices acute, the edges of the wings irregularly crenate (FIG. 6).

Telia similar to the uredinia, the teliospores adhering to form short columns; teliospores obovoid-fusoid, excluding the apex,  $12-18 \times 38-44 \mu$ , the apex long attenuate,  $25-50 \mu$  long, the wall hyaline, the inner  $1 \mu$ , the outer thinner and separating from the inner (FIG. 13).

**SPECIMENS EXAMINED:**

*Sapindus bifoliatus* Hiern, Sigiriya, Ceylon, Aug. 1912, T. Petch, 3565, type.

According to Sydow (14), Petch reported this collection as *Uredo cristata* Speg. Sydow (14) described it as a species in *Ctenoderma*, the urediniospores being described as teliospores. A few telia have been found accompanying the uredinia. These



FIGS. 9-14. Teliospores of species of *Skierka*,  $\times 600$ : 9, *S. congonensis*; 10, *S. philippinensis*; 11, *S. Canarii*; 12, *S. cristata*; 13, *S. Petchii*; 14, *S. Holwayi*.

contain teliospores typical of the genus *Skierka*. The urediniospores also are characteristic of that genus. The species is nearer *S. Holwayi* than *S. cristata*. The long attenuate apices of the teliospores and the lateral thickenings of the wall of the urediniospores approach those of the former species.

SKIERKA HOLWAYI Arth. Am. Jour. Bot. 5: 433. 1918.

Pycnia amphigenous, in small groups, subepidermal, discoid, 350-450  $\mu$  wide, 90-130  $\mu$  thick.

Primary uredinia mostly epiphyllous, in groups surrounding the

pycnia, developing immediately beneath the greatly enlarged epidermal cells, flask-shaped, covered by a layer of compacted hyphae beneath the epidermis, opening by a pore, the urediniospores sometimes emerging in sporehorns, which easily disintegrate in water. Secondary uredinia rare, scattered, subepidermal, the epidermal cells not enlarged; urediniospores as bounded by the inner wall narrowly obovoid,  $14-20 \times 30-65 \mu$ , the inner wall yellowish-brown, uniform in thickness,  $2-2.5 \mu$ , the outer wall hyaline, swelling laterally to form a plate reaching  $26-36 \mu$  in width longitudinally surrounding the spore except for the hilum, with this plate in the optical plane the spores ovate or cordate in outline,  $26-36 \times 30-65 \mu$ , acute at the apex, appearing smooth except for the edges of the plate which are irregularly crenate (FIG. 7).

Telia, mostly hypophyllous, accompany the pycnia and primary uredinia and then similar to the latter, sometimes scattered and then not causing enlargement of the epidermal cells, the teliospores adhering and forming long yellowish columns; teliospores fusoid,  $11-14 \times 28-38 \mu$  exclusive of the apex which is very slender, reaching a length of  $60 \mu$ , the apex disintegrating in water, the wall smooth, hyaline, of two layers, the inner  $1.5 \mu$ , the outer  $1 \mu$  or less and separating from the inner (FIG. 14).

#### SPECIMENS STUDIED:

*Thouinidium decandrum* (H. B. K.) Radlk. Sanarate, Guatemala, Feb. 10, 1916, E. W. D. Holway, 475; Amapala, Isla Tigre, Honduras, Feb. 14, 1922, Paul C. Standley, 20730a; San Miguel, El Salvador, Feb. 24-27, 1922, Paul C. Standley, 21081.

*Thouinidium* sp. Agua Caliente, Guatemala, E. W. D. Holway, 849 (type).

This is a most unusual rust. In this species many of the characters stressed in the other species find their extreme development. The outer wall of the urediniospores swells unequally in water to form a broad and thick plate surrounding the spore longitudinally except for the hilum. This extension of the wall is so broad that in mounts for the microscope the spores nearly always orient themselves with the plate in the optical plane and the spore can be rotated with difficulty. The urediniospores sometimes adhere and emerge from the uredinia in sporehorns. They, however, readily separate in water. The teliospores adhere and are forced through the narrow opening of the telium in long columns. They separate less readily than in other species. The teliospores have very long filiform apices and the wall of the spore separates



into two layers. In water the apex disintegrates. This leaves the outer layer free from the inner except at the base of the spore.

SKIERKA AGALLOCHOA Racib. Bull. Acad. Sci. Cracovie. 1909: 275.

Specimens of this species have not been available. It is apparently known only from the original collection obtained at Batavia, Java on *Excoecaria Agallocha*. Only telia are described. The teliospores are given as  $8-12 \times 60-100 \mu$ , smooth, thin-walled, the apex  $18-25 \mu$ . The teliospores are forced through the opening of the telium in threads  $50-80 \mu$  wide and 1-8 mm. long.

SKIERKA ROBUSTA Doidge, Bothalia 2: 155-156. 1926.

Specimens of this species have not been available. Only telia are described on *Rhoicissus rhomboidea* from South Africa. The teliospores are given as yellowish, narrow-lanceolate or lanceolate-fusiform,  $20-27 \times 120-180 \mu$ , acuminate, elongated into a long filiform process, the wall 3-3.5 (5)  $\mu$ .

CTENODERMA TODDALIAE (Petch) Sydow, Ann. Myc. 17: 103. 1919.

*Aecidium Toddaliae* Petch, Ann. Roy. Bot. Gard. Peradeniya 4: 303. 1909.

*Uredo Toddaliae* Petch in Sydow, Fungi exotici exsiccati 69. 1913.

Pycnia amphigenous, grouped in yellowish spots, discoid,  $150-200 \mu$  wide,  $50-75 \mu$  thick, filaments lacking.

Uredinia hypophyllous, surrounding the pycnia, deep seated in the host tissue, opening by a small pore or slit; urediniospores very angular,  $28-36 \times 40-70 \mu$ , the inner wall yellowish-brown, uniform,  $1.5 \mu$ , the outer wall hyaline, very thin over most of the spore, thickened irregularly to form ridges of various extents mostly over the apex or at the base, occasionally from base to apex, up to  $10 \mu$  thick, irregularly and finely echinulate, specially on the ridges (FIG. 8).

SPECIMENS EXAMINED:

*Toddalia aculeata*, Hakgala, Ceylon, Aug. 30, 1912, T. Petch, Sydow, Fungi exot. 69.

Only pycnia and uredinia were found on the specimen studied. This is probably a species of *Skierka*. The urediniospores have the outer wall thickened in ridges which are less regular than in the other species. Until telia are discovered it seems best to leave this species under the name *Ctenoderma Toddaliae*.

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## EXPLANATION OF FIGURES

FIG. 1-4. Urediniospores of species of *Skierka* with lateral thickenings of the wall in the optical plane,  $\times 600$ : 1, *Skierka congonensis*; 2, *S. philippinensis*; 3, *S. Canarii*; 4, *S. cristata*.

FIG. 5-8. Urediniospores of species of *Skierka* and *Ctenoderma* with lateral thickenings of the wall in the optical plane,  $\times 600$ : 5, *S. Diploglottidis*; 6, *S. Petchii*; 7, *S. Holwayi*; 8, *Ctenoderma Toddaliae*.

FIG. 9-14. Teliospores of species of *Skierka*,  $\times 600$ : 9, *S. congonensis*; 10, *S. philippinensis*; 11, *S. Canarii*; 12, *S. cristata*; 13, *S. Petchii*; 14, *S. Holwayi*.

# STUDIES ON HISTOPLASMA CAPSULATUM AND SIMILAR FORM SPECIES—I. MORPHOLOGY AND DEVELOPMENT<sup>1</sup>

ARDEN HOWELL, JR.<sup>2</sup>

(WITH 5 FIGURES)

## INTRODUCTION

The identity of the organism which is the etiological agent of the disease in man known as histoplasmosis has long been in question. The disease was originally described by Darling (4, 5, 6) as a result of his studies among the natives of Panama when first he encountered a case characterized clinically by emaciation, splenomegaly, leucopenia, anemia, and irregular pyrexia. Subsequently an autopsy upon the patient revealed that the pathological features were as follows: "The invasion of the endothelial cells in the smaller lymph and blood vessels and capillaries by enormous numbers of a small, encapsulated micro-organism causing necroses of the liver with cirrhosis, splenomegaly, pseudo-granulomata of the lungs, small and large intestines, with ulceration of the latter, and necrosis of the lymph nodes draining the infected viscera."

The organism, which Darling regarded as the cause of the disease that produced this condition, occurred in the tissues as small, round to oval cells, 1-4  $\mu$  in diameter, some of which Darling thought possessed flagella. Although he admitted these forms resembled the Leishman-Donovan bodies of kala-azar they differed from the latter in several respects, and hence were regarded by

<sup>1</sup> Contribution No. 163 from the Laboratories of Cryptogamic Botany and the Farlow Herbarium, Harvard University.

<sup>2</sup> The author is greatly indebted to Dr. David H. Linder, under whose direction the present investigations were conducted, for the material he provided to begin the work, for his many valuable suggestions, assistance, advice, and encouragement, and for the manner in which he gave so unstintingly of his time. Also he wishes to express his gratitude to Dr. William H. Weston, Jr., for his constructive criticism and for his helpful co-operation throughout the work.

Darling as a hitherto undescribed protozoön parasite to which he gave the name *Histoplasma capsulatum*. Two additional cases of this disease were observed by Darling within the next few months, but all attempts to cultivate the organism failed.

Following Darling, the disease was reported by Riley and Watson (17), and Crumrine and Kessel (3) from Minnesota and California respectively. It was not until 1934 that the first successful attempt to grow the pathogen in artificial culture was made by de Monbreun (7) who isolated the organism from the spleen of an infant that had died of the disease in 1932 in Tennessee. The results of his study showed the parasite to be of fungal nature and that the life history was divided into two phases, a parasitic, yeast-like phase which germinated to produce the saprophytic, mycelial phase in culture. The only means found thus far to reconvert the mycelial form into the yeast-like phase has been to inoculate the mycelial form into susceptible animals. From the lesions so produced, the yeast-like form has been obtained on suitable culture media.

In an attempt to place this organism in a system of classification de Monbreun compared it with such forms as *Endomyces capsulatus* Rewbridge, Dodge, and Ayers (16). This fungus was isolated from a nodule on the surface of the medulla in a case which had been diagnosed as meningoencephalitis with complicating tuberculosis. In the lesions this *Endomyces* occurred exclusively as budding cells, but on artificial culture media it developed a mycelial form quite similar to that described for *Histoplasma*. However, de Monbreun made no definite attempt to classify *H. capsulatum* other than to point out the similarities between its life cycle and cultural characteristics and those of *Endomyces*.

Later Hansmann and Schenken (9) isolated a fungus from a patient suffering from a generalized skin infection very similar to histoplasmosis. The authors considered this fungus was not identical with *Histoplasma capsulatum* but was rather a pathogenic species referred tentatively to the genus *Sepedonium*.

That the fungus described by Hansmann and Schenken (9) as a parasitic *Sepedonium* was identical, or nearly so, with *Histoplasma capsulatum* Darling has been established by Moore (15) and others. Since, however, Moore erroneously considered the

large, tuberculate, ascus-like bodies mentioned by de Monbreun (7) as occurring on the mycelia produced by these two organisms on artificial culture media to be true asci containing endospores, he transferred these fungi to the genus *Posadasia*. Inasmuch as Moore also observed certain cultural and morphological differences between the two strains, he created the species *Posadasia pyri-formis* Moore for the fungus isolated by Hansmann and Schenken, and *Posadasia capsulata* (Darling) Moore for the form first cultured by de Monbreun (7).

The genus *Posadasia* was established by Canton (1) for the organism which was the etiological agent of coccidioidal granuloma in South America. In the tissues this parasite usually exists as large, thick-walled cells which are transformed directly into asci containing an indefinite number of ellipsoidal spores. Moore (14, 15) noticed the resemblance of these asci to the ascus-like bodies (or so-called "asci") produced on the mycelium of *Histoplasma* on artificial culture media, and presumed that they were homologous structures. It was on this basis that Moore made the generic transfer.

On the other hand, Dodge (8) reduced the genus *Posadasia* to synonymy with the genus *Coccidioides* Stiles, the latter having been created for the organism which was the etiologic agent of coccidioidal granuloma in North America, inasmuch as he, Dodge, believed the two parasites which had been described as the causative agents of this disease were identical. He then retained the name *Histoplasma capsulatum* for the organism described by Darling (4), making *Posadasia capsulata* (Darling) Moore a synonym of this form, and likewise created the new combination *Histoplasma pyriforme* (Moore) Dodge for the organism described by Moore from the case of histoplasmosis isolated by Hansmann and Schenken. He then placed the genus *Histoplasma* in the family Coccidioideaceae of the Endomycetales with the genera *Coccidioides*, *Paracoccidioides*, and *Rhinosporidium*. Each of these produce similar lesions in man, are more or less similar in their parasitic phases and are similar in culture, inasmuch as each, in culture, produces structures that have been regarded as naked, multi-spored asci. According to Moore (15) and Dodge (8) these genera differ in that the "asci" in *Coccidioides* are

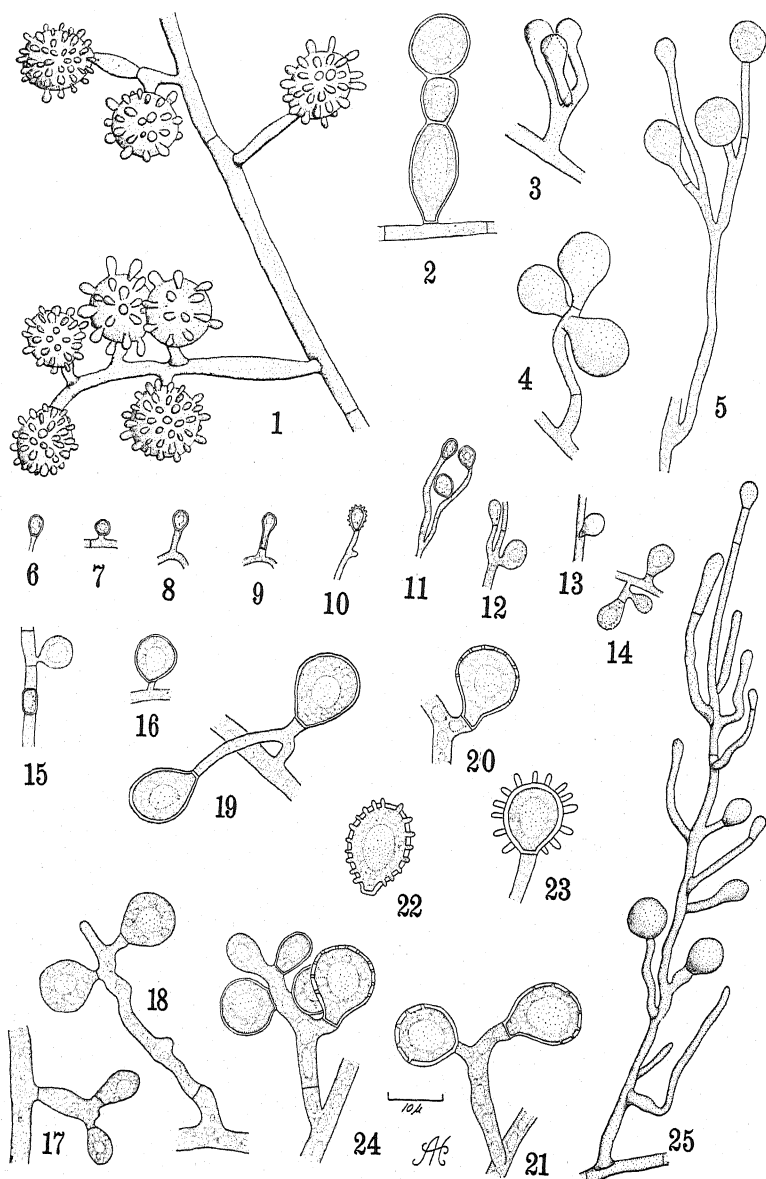


FIG. A. *Histoplasma capsulatum* Darling.

smooth-walled; in *Histoplasma* bear functionless tubercles on the walls; in *Paracoccidioides* bear tubercles into which the "ascospores" migrate and from which they are then discharged by the rupture of the walls; while in *Rhinosporidium* the "asci" open by a definite pore.

In a recent paper Ciferri and Redaelli (2), after making a careful study of *Histoplasma capsulatum* Darling and *H. pyriforme* (Moore) Dodge, reduced the latter species to synonymy with *H. capsulatum* because of the fact that the two species are identical morphologically. They, therefore, listed the following synonymy:

HISTOPLASMA CAPSULATUM Darling, 1906.

*Cryptococcus capsulatus* Neveu Lemaire, 1921.

*Posadasia capsulata* Moore, 1934.

*Posadasia pyriformis* Moore, 1934.

*Sepedonium* sp. Hansmann & Schenken, 1934.

*Histoplasma pyriforme* (Moore) Ciferri & Redaelli, July, 1935.

*Histoplasma pyriforme* (Moore) Dodge, August, 1935.

Furthermore, they placed the genus *Histoplasma* in the new family Histoplasmaeaceae which they included in a super-family of non-sporogenous yeasts, the *Adelosaccharomycetaceae* Guill. as emended by Ciferri (1930).

It is readily seen that much confusion exists as to the exact identity and classification of the organism which is the etiological agent of Darling's histoplasmosis. It is the aim of this paper, therefore, to determine its true identity and taxonomic position, first, by presenting a detailed account of its life history and development with ample descriptions and illustrations, and second, by comparing these with the life cycles and spore forms of existing genera of saprophytic or parasitic fungi to which it has been referred. To supplement the present work the writer has also undertaken a comparative study of the biological reactions of representative species of these fungi in pure culture as well as an examination of the interrelationships of these species through serological studies and through experimental inoculations.

#### MATERIALS AND METHODS

These studies were made with pure cultures, the fungi used having been obtained from the following sources: *Histoplasma*



*capsulatum* Darling, *H. pyriforme* (Moore) Dodge, originally from de Monbreun (7) and Hansmann (9) respectively, deposited in the culture collection of the Cryptogamic Laboratory as No. M250 and No. M251; *Sepedonium chrysospermum* (Bull.) Lk., No. M283, from Dr. D. H. Linder who isolated it from *Boletus* sp.; *S. xylogenum* Sacc., No. M281, and *Stephanoma tetracoccum* van Zinderen-Bakker (18), No. M273, from Dr. Linder who obtained *S. xylogenum* Sacc. from an original isolate from decayed wood by Dr. R. Thaxter and *S. tetracoccum* from an original isolation from *Geoglossum Farlowii* by Dr. Linder; and *Mycogone perniciosa* Magn., No. M280, and *Chlamydomyces palmarum* (Cooke) Mason, No. M279 from the Centraalbureau voor Schimmelcultures, Baarn, Holland.

Various media, such as Sabouraud's maltose agar, four per cent sucrose (Merck) agar, one per cent Difco Bacto-peptone agar, and potato maltose agar were used for general cultural work. The latter medium, because of the fact that it was readily available, easily prepared, and proved very satisfactory for the growth of all species concerned, was chiefly used. This medium was prepared from a decoction of 100 grams of potato per liter to which was added two grams of Pfanstiehl's technical maltose and twenty-five grams of Difco Bacto-agar. To insure uniformity of the medium, four to eight liters of the decoction were made up at one time, and agar was added when needed.

Observations were usually made from Petri dish cultures or slide cultures, the latter being a modification of Unna's technique, recommended by Langeron (10), and essentially the same as that described by Martini et al. (12). In this process the fungus grows over a slide which has been placed below the surface of the agar in a Petri dish. Whenever desired, the slide is removed from the Petri dish, allowed to dry at room temperature for twenty-four to thirty-six hours, during which time the agar is dehydrated, and the slide is then stained with lactophenol cotton-blue (11) for 15 to 20 minutes. At the end of this time they are immersed in 70 per cent alcohol for 10 to 15 minutes, and then dehydrated and mounted in balsam.

Many observations of the fungi in Petri dishes or test tubes

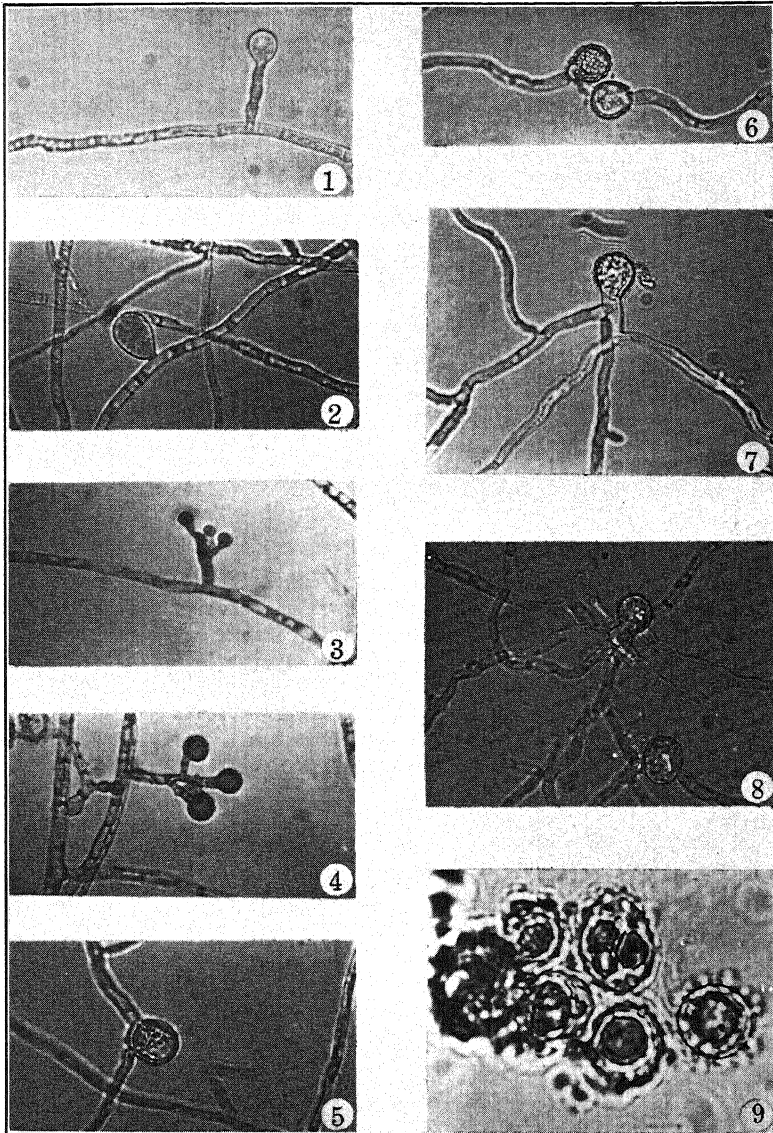


FIG. B. *Histoplasma capsulatum* Darling.

were supplemented by studies of cultures in van Tieghem cells, especially in following the germination of spores.

All cultures, unless otherwise noted, were grown at room temperature, which averages about 22° C.

#### LIFE HISTORIES

##### HISTOPLASMA CAPSULATUM Darling.

The life cycle of *Histoplasma capsulatum* Darling, like that of many of the parasitic fungi, is rather complicated, inasmuch as the habitat determines the character of the growth. As was pointed out in the introduction it exists in the tissues as small, oval, yeast-like bodies, measuring about  $3 \times 3.5 \mu$  in diameter. Each cell is surrounded by a thin membrane, and, in unstained preparations, usually contains one or more small, refractile fat droplets in addition to a single protoplasmic granule in active Brownian movement. Also, in stained preparations, there may appear one or more vacuoles in each cell, and a nucleus which usually appears as a peripheral, crescentic mass of chromatin. One pole of the cell is usually pointed, and when buds occur they do so singly and only at the pointed ends of the cells. The yeast-like form will persist, if upon isolation from the natural host, it is kept on blood or serum agars at 37° C. and transferred at short intervals. The mycelial form of the fungus develops directly from the yeast-like cells by a process of elongation to form mycelial growths which soon become septate.

The preceding description of the yeast-like phase of *Histoplasma capsulatum* has been adapted from de Monbreun's paper (7) since this phase has not yet been studied by the present writer whose observations follow.

The mycelium varies from 2 to 5  $\mu$  in diameter, and is usually highly refractile, branched, and multicellular, though its appearance may vary somewhat depending on the type of culture medium employed. As the mycelium matures, the walls become slightly thickened, and within the hyphae a large number of fat globules and vacuoles are formed (FIG. B: 1-4).

After varying lengths of time, depending on the medium employed and the conditions under which the culture develops, sporulation begins.

It would appear at first glance that there are at least three types of spores produced (FIG. *A*: 1, 6-9, 25). First, there are large, tuberculate, spherical to pear-shaped bodies or spores, 10-25  $\mu$  in diameter, sessile or on short pedicels, produced on the aerial mycelium (FIG. *A*: 1); secondly, smooth-walled, round to oval spores, varying in diameter from 5 to 20  $\mu$ , usually formed on short pedicels, and on the submerged mycelium (FIG. *A*: 2, 5, 25); and thirdly, small, smooth-walled spores, spherical to pyriform, 2-6  $\mu$  in diameter, sessile or on short stalks, produced on the aerial or submerged mycelium (FIG. *A*: 6-10).

The large, tuberculate, aerial spores begin their development as bulbous enlargements of the terminal ends of lateral branches. These branches may be simple with a single spore at the terminal end (FIG. *B*: 1; FIG. *A*: 18) or divided into two to several short branches, with a single spore developed on the terminal end of each branch or one to several are produced acropetally and directly on a short branch (FIG. *A*: 3, 4, 17, 24; *B*: 3). As these spore initials increase in size, each one is cut off from the rest of the hyphae by a cross wall near the base, become spherical to pyriform in shape, and the wall gradually increases in thickness (FIG. *A*: 19, 24). Simultaneously, there usually develops a large central vacuole, and shortly thereafter definite softening or pits appear in the walls (FIG. *A*: 20) through which papillate protoplasmic outgrowths protrude to form an indefinite number of finger-like processes (FIG. *A*: 21, 22). As the spores mature these papillae increase in size and are finally cut off from the protoplasmic content of the spores by the formation of a secondary inner wall (FIG. *A*: 23). When fully developed they contain numerous globules, often very uniform in size, which simulate endospores (FIG. *B*: 9). However, these globules are stained intensely by osmic acid, Sudan III and Scharlach R,<sup>3</sup> and disappear entirely when mounted on a slide in lactophenol and heated slightly. Furthermore, it has been observed that when they are treated with Scharlach R or Sudan III, then mounted in glycerine and allowed to stand several weeks, the globules coalesce to form

<sup>3</sup> Saturated alcoholic solutions of Scharlach R and Sudan III were used, prepared by dissolving 0.2 gm. of each in 100 c.c. 70 per cent alcohol; osmic acid was used in the form of vapor from a 2 per cent aqueous solution.

a single, more or less spherical droplet occupying the center of the spore. Since the osmic acid and stains mentioned are generally considered specific for fatty substances, the author regards these bodies as fat globules, and has been unable to find any evidence of true endospores within these large, tuberculate, so-called ascus-like bodies.

Inasmuch as the classification of this organism depends upon the nature of these tuberculate spores, it seems wise to consider briefly here the interpretations that have been placed upon them.

These bodies were first observed by de Monbreun (7), who proposed the term "ascus-like bodies or cells" as a temporary name for them since they resembled asci because of the numerous fat globules, simulating endospores, which they contain. He emphatically stated, however, that they could not be called asci since he failed to observe true endospores or any sexual phenomena in direct association with them. Likewise, Hansmann and Schenken (9) failed to find evidence of endospores within these tuberculate cells. They also observed the same round, hyaline bodies which simulated endospores, but they reported that these endospore-like structures absorbed fuchsin and Sudan III, disappeared upon heating, and failed to survive fixing and staining methods. Hence they considered the ascus-like cells of de Monbreun to be chlamydospores containing one to several globules of a fatty substance.

On the other hand, Moore (15) supposedly found true endospores within these ascus-like cells apparently in addition to the fat globules observed by de Monbreun (7), Hansmann and Schenken (9), and the present author. Moore states that "cytological investigations show that the single ascus contains a number of spherical spores which are set free by a rupture of the ascus wall to germinate and commence another cycle," but that "when in a nutrient condition, the ascus may germinate with few to several germ-tubes which develop into a mycelium." Furthermore, he figures these ascospores and their germination in plate 11, figure 1 and plate 13, figure 72 of his paper. Later in his paper, however, he refers to these same two figures as conidia which "break off easily from the hyphae and germinate to give rise to a new colony serving much the same purpose as do the

ascospores." In view of the conflicting references to plate 11, figure 1 and plate 13, figure 72 by Moore (15) and also because he has failed to show either fusion of nuclei or the meiotic division characteristic of the development of ascospores within an ascus, the writer feels that Moore has not shown the tuberculate structures to be asci. It is therefore impossible to accept Moore's conclusions.

The writer has repeated the technique used by Moore, insofar as it was possible to ascertain the methods used from the meager descriptions given in his paper, and has failed to find any evidence whatever for the presence of endospores within these tuberculate cells. As it has already been pointed out, there are numerous bodies, quite uniform in size, within these cells, but in view of the evidence already presented, both by the present author and previous workers with the exception of Moore, it can hardly be doubted that these bodies are fatty in nature and that there are no endospores present. Hence the structures in question cannot be considered as asci. The question then arises as to what term should be applied to these aerial, tuberculate spores. It seems clear, from the development of these as previously described in this paper (FIG. A, B), and from the work of others (7, 9) that according to the terminology proposed by Mason (13) they should be given the name *aleuriospores*. This name was given by Vuillemin (19) to certain terminal chlamydospores which are similar to conidia in color, position, size, form, and structure, but which differ from true conidia in that they are not immediately freed from the mycelium by a natural means of dehiscence.

In addition to the large, tuberculate, aerial *aleuriospores* there develop large, smooth-walled spores (FIG. A: 2, 5, 25) below the surface of the agar and minute entities (FIG. A: 6-10), called conidia by Moore, which are formed in old cultures and are obviously depauperate structures. That both these types are modifications of the tuberculate, normal, aerial *aleuriospores* there can be little doubt since a study of a large number of cultures has demonstrated that all spores not only develop in the same manner and that there is a gradual transition between them, but also they germinate in the same fashion.

Neither phialospores nor *conidia vera* have been encountered

by the author in this species, nor have any been reported by previous workers.

Germination of the aleuriospores, from a ten weeks old culture, takes place readily. Within fifteen to twenty hours after they were inoculated either into a two per cent Difco Bacto-peptone or Difco proteose peptone or potato-maltose broth well-developed germ tubes could be seen growing out from nearly all of the aleuriospores used in the preparation (FIG. B: 5-8). In the majority of cases there develops a single germ tube which may remain unbranched for some distance (FIG. B: 6) or may even branch immediately upon its emergence from the spore so that, although it would appear that there were several germ tubes, closer observation demonstrated that there was in reality only a single germ tube giving rise to one or more branches (FIG. B: 7). In a number of instances the germ tube enlarged into a globose structure immediately upon its emergence from the aleuriospore, and then from this there arose two to several hyphae (FIG. B: 8). It should be pointed out at this point that if such a structure were seen from above the spore rather than from the side it would give the impression that the aleuriospore germinated by producing many germ tubes. The author questions, consequently, if it were not such a phenomenon that Moore (15) observed which he has described and figured as an ascus which, in a nutrient condition, had germinated with few to several germ tubes in plate 12, figure 71 of his paper. In a few cases two separate and distinct germ tubes were seen to arise from a single aleuriospore (FIG. B: 5) and rarely three, but the author has never observed more than this. Whether two or three germ tubes were produced from a single aleuriospore, they always arose from the same pole.

Once the germ tube is formed, growth proceeds rapidly. The hyphae begin to branch and soon become multicellular by the formation of cross walls or septa at more or less regular intervals. As they mature, they become vacuolate and replete with fat globules. Finally, within twenty-five to forty hours after the germ tubes have emerged from aleuriospores germinated on two per cent peptone or potato-maltose broth in van Tieghem cells, sporulation begins, the aleuriospores being formed in the manner already described.

The genus *Histoplasma*, then, may be characterized as a fungus parasite in the life cycle of which there are two distinct phases. The first or parasitic phase consists of small, oval, yeast-like bodies,  $3 \times 3.5 \mu$  in diameter, which reproduce by budding, and exist primarily in the endothelial cells of the smaller lymph and blood vessels and capillaries of the host. The second or saprophytic phase, derived directly from the first, consists of a typical fungus mycelium which usually appears as a white and cottony growth in culture. The hyphae composing this mycelium vary from  $2.5$  to  $5 \mu$  in diameter, and bear numerous aleuriospores, either sessile or on short pedicels. These spores vary in shape from spherical to pyriform, in size from  $2$  to  $25 \mu$  in diameter, the majority ranging from  $12$  to  $20 \mu$ , and contain from one to several, round to ovoid, fat globules. Their walls may vary from smooth to highly tuberculate, depending on whether the spores are produced on mycelium that is submerged, on that near the surface of the agar, or that which is strictly aerial. When tuberculate, the tubercles may vary from small, wart-like processes to long, finger-like projections,  $1$  to  $7 \mu$  in length.

SEPEDONIUM CHRYSOSPERMUM (Bull.) Link.

The life history and morphology of *Histoplasma* outlined above can now be compared with the genus *Sepedonium*, using *S. chrysospermum* (Bull.) Link, the type of the genus, as an example.

The mycelium of this species is composed of hyphae which vary from  $2-4 \mu$  in diameter and are usually hyaline, thin-walled, branched, and multicellular. As they mature they may become very vacuolate. When the mycelium is fairly well-developed, sporulation begins, though the time of sporulation may vary somewhat, depending on the conditions under which the culture develops.

There are at least two types of spores usually produced in culture. First, there are large, yellow to golden, warted or tuberculate, spherical aleuriospores, which begin their development as small, bulbous enlargements of the terminal ends of lateral branches of the surface or aerial mycelium. These branches may occasionally be single with a single spore at the tip, but usually divide further into a number of branches, each of which gives



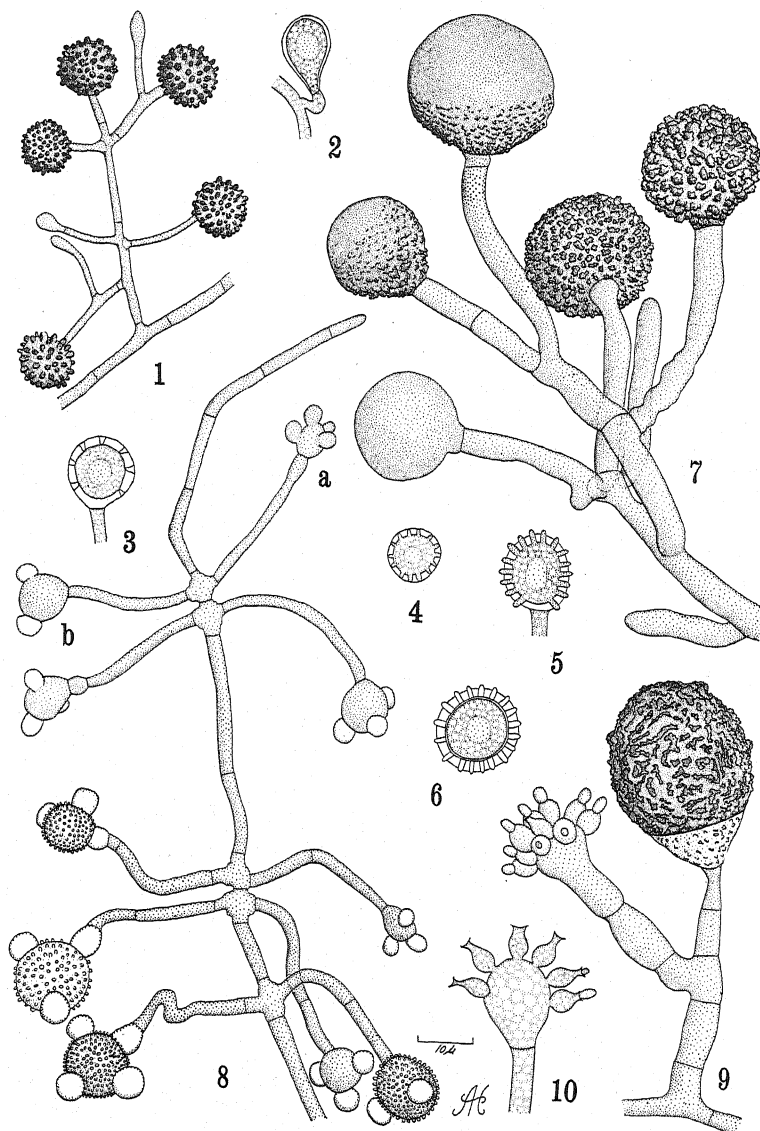


FIG. C. 1-6, *Sepedonium chrysospermum* (Bull.) Link; 7, *Sepedonium xylogenum* Sacc.; 8, *Stephanoma tetracoccum* van Zinderen-Bakker; 9, 10, *Chlamydomyces palmarum* (Cooke) Mason.

rise to a spore, so that eventually a cluster of aleuriospores is produced (FIG. C: 1). As these spore initials increase in size each one becomes separated from the remainder of the subtending hypha by the formation of a septum at its base, the wall increases in thickness and a large, central vacuole appears (FIG. C: 2). Immediately following this, definite pits or softening in the wall make their appearance and through these protoplasmic outgrowths protrude to form short papillae (FIG. C: 3-5). At a slightly later stage these papillae are cut off from the protoplasmic content of the spore by the formation of a secondary inner wall (FIG. C: 6). As the spores continue to mature the outer wall becomes yellow to golden in color, and when fully developed the aleuriospores bear an indefinite number of these short, blunt papillae, varying from 1 to  $1.5\ \mu$  in length, the spores being  $14-16\ \mu$  in diameter. This process of spore formation and the production of the ornamentation is identical with that found in *Histoplasma capsulatum*, and shows these structures to be homologous in the two species. Thus additional evidence is added to substantiate the belief that the tuberculate structures of *Histoplasma capsulatum* should be thought of as aleuriospores, and not as asci.

The germination of the aleuriospores of *S. chrysospermum* is essentially similar to that already described for the homologous spores of *Histoplasma*, except that there is apparently only a single germ tube produced in *S. chrysospermum*. This process has been repeatedly observed in van Tieghem cells using either a two per cent Difco Bacto-peptone or Difco proteose peptone broth. The aleuriospores used in these studies were obtained from a five-months-old potato maltose agar culture. Within twenty to twenty-four hours after they were inoculated on the Bacto-peptone broth, short germ tubes, one from each spore, appeared. Those on the proteose-peptone broth took much longer to germinate, the germ tubes not appearing for about seventy-two hours. Once the germ tube is formed, growth proceeds rapidly, the hyphae soon becoming branched, and septate, with the branching frequently occurring at a characteristic acute angle (FIG. E: 3, 4). Finally, after sixty to seventy-two hours on the Bacto-peptone or after about five days on the proteose-peptone preparations, a second type of spore is produced, which, although formed before the

aleuriospores when the fungus is grown in culture, is for convenience given secondary position in this discussion. These spores, called phialospores, have not been observed by the writer, nor by any of the previous investigators, in cultures of *Histoplasma*.

The phialophore, which produces the phialospores, begins its development as a short lateral outgrowth from a hypha of the surface or aerial mycelium and by continued elongation and branching eventually forms the much-divided phialophore bearing subulate or tapering terminal cells which are known as phialides (FIG. D: 3). From, or within the apex of these phialides the thin-walled phialospores are abstricted (FIG. E: 1). Additional spores may be successively formed at the apex of a single phialide, in which process the first-formed spore is pushed aside (FIG. E: 2). This procedure may continue until several spores have been produced and, accumulating around the tip of the phialide, form a globose mass as a result of the adhesion of the spores. The mature phialospores are ovoid in shape, smooth-walled, hyaline, and  $8-11 \times 5-6 \mu$  in size (FIG. D: 3). It is possible that these spores may serve an additional purpose in that they may function as spermatia in the sexual reproduction of the ascigerous stage, *Hypomyces chrysospermus* (Bull.) Tul., of which *Sepedonium chrysospermum* is the asexual or imperfect stage. The germination of the phialospores has also been observed, and is essentially similar to that of the aleuriospores, the germ tube usually arising at one pole of the spore. Occasionally a second germ tube arises at the opposite pole.

#### SEPEDONIUM XYLOGENUM Sacc.

For further study of the life history and morphology of *Sepedonium* in comparison with *Histoplasma* another species, *Sepedonium xylogenum* Sacc., was examined by the writer. In this form the aleuriospore has been the only type of spore developed in culture, and, so far as the writer has been able to determine, is the only spore form known. In this species the development of the aleuriospore is very similar to that of the same type of spores of *S. chrysospermum* and *Histoplasma* previously described. In addition their germination is essentially similar to

that described for *S. chrysospermum*, except that one, two, or three germ tubes may arise, whereas only one was produced in *S. chrysospermum* (FIG. E: 5-6). In those cases in which two or more germ tubes arise, they do so singly and at points on the spore equidistantly apart (FIG. E: 6).

In addition to the aleuriospores developed on the surface or aerial mycelium of *S. xyloenum*, there are small, bullate cells, resembling those of *Rhizoctonia*, though apparently not serving for vegetative reproduction, which are characteristically produced on the submerged mycelium (FIG. E: 7). These structures may be terminal or intercalary and are formed by a rounding up of the cells of the hyphae.

It can be seen from the preceding statements that there is a marked difference between this species and the two preceding. Aside from the lack of phialospores, the method of aleuriospore formation also distinguishes it. It may be recalled that at the beginning of the formation of papillae in those species pits or softened areas make their appearance in the walls, and then protoplasmic outgrowths protrude through the pores to form the finger-like processes. In *S. xyloenum*, on the contrary, no pits appear in the wall, but rather there is a local folding which proceeds from the base towards the apex of the spore (FIG. C: 7). These minute folds become thickened and eventually form the wart-like ornamentation. This difference in spore development, plus the fact that phialospores have not been observed, strongly suggests that *S. xyloenum* should be placed in some other genus. However, for the present, and since the Fungi Imperfecti are admittedly divided along artificial lines, it seems best to leave this species in the genus until it is possible to show actual connections between it and a perfect stage.

#### STEPHANOMA TETRACOCUM van Zinderen-Bakker.

Another species possibly related to *Sepedonium chrysospermum* (Bull.) Link through its ascigerous stage, *Hypomyces*, is a fungus of which the conidial stage is *Stephanoma tetracocum* van Zinderen-Bakker, parasitic on *Geoglossum*. In this species the aleuriospores begin their development as small, bulbous enlargements of the terminal ends of lateral branches of the surface or aerial

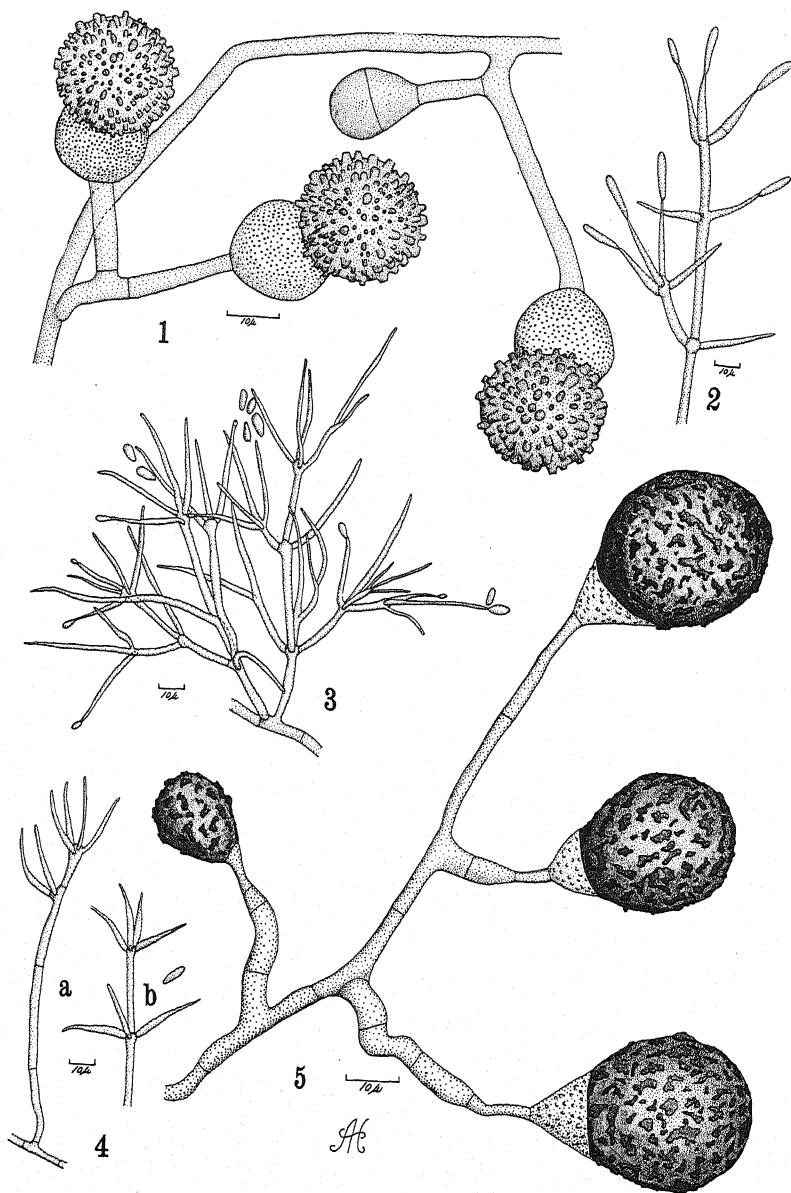


FIG. D. 1, 2, *Mycogone pernicioso* Magn.; 3, *Sepedonium chrysospermum* (Bull.) Link; 4, *Stephanoma tetracoccum* van Zinderen-Bakker; 5, *Chlamydomyces palmarum* (Cooke) Mason.

mycelium. Simultaneously, three to six globose or bullate swellings, which arise as rounded protrusions of the cell wall resulting, supposedly, from local action and pressure exerted by the protoplasm, develop on the aleuriospore initials (FIG. C: 8a). Shortly thereafter the spore is separated from the remainder of the hypha by a septum at its base, following which the bullate processes mentioned above are cut off from the protoplast of the spore either by septa at the bases of these swellings or by the formation of a secondary wall. Following this the protoplasmic content of the cell-like, sterile structures disappears (FIG. C: 8b). The remainder of the development of these aleuriospores, including the formation of the smaller echinulations, is identical with that previously described for the homologous spores of *Histoplasma* and *Sepedonium chrysospermum*, yet because of the fact that the bullate processes on the aleuriospores of *Stephanoma tetracoccum* are formed very early in their development, it differs from *Sepedonium chrysospermum*.

This species, although the fact has not been recorded by van Zinderen-Bakker (18), also produces in culture as well as on the natural substratum a second spore form, the phialospores (FIG. D: 4), which develop in the same manner as the phialospores of *Sepedonium chrysospermum* previously described.

In view of the fact that *Hypomyces Geoglossi* Ellis & Ev. has been observed in the field to be associated with this imperfect stage and also because *S. tetracoccum* produces the *Verticillium* type of phialospore, there is the strong possibility that it is related to *Sepedonium*. Since the formation of the smaller spines follows in the same manner as does that of *Sepedonium chrysospermum*, the bullate appendages need not be a source of confusion since they may be considered a secondary development.

CHLAMYDOMYCES PALMARUM (Cooke) Mason.

MYCOGONE PERNICIOSA Magn.

Two other species possibly related to *Sepedonium* through their ascigerous stages are *Chlamydomyces palmarum* (Cooke) Mason and *Mycogone perniciosa* Magn., both of which produce aleuriospores and phialospores in culture.

The aleuriospores of *Chlamydomyces palmarum* are essentially

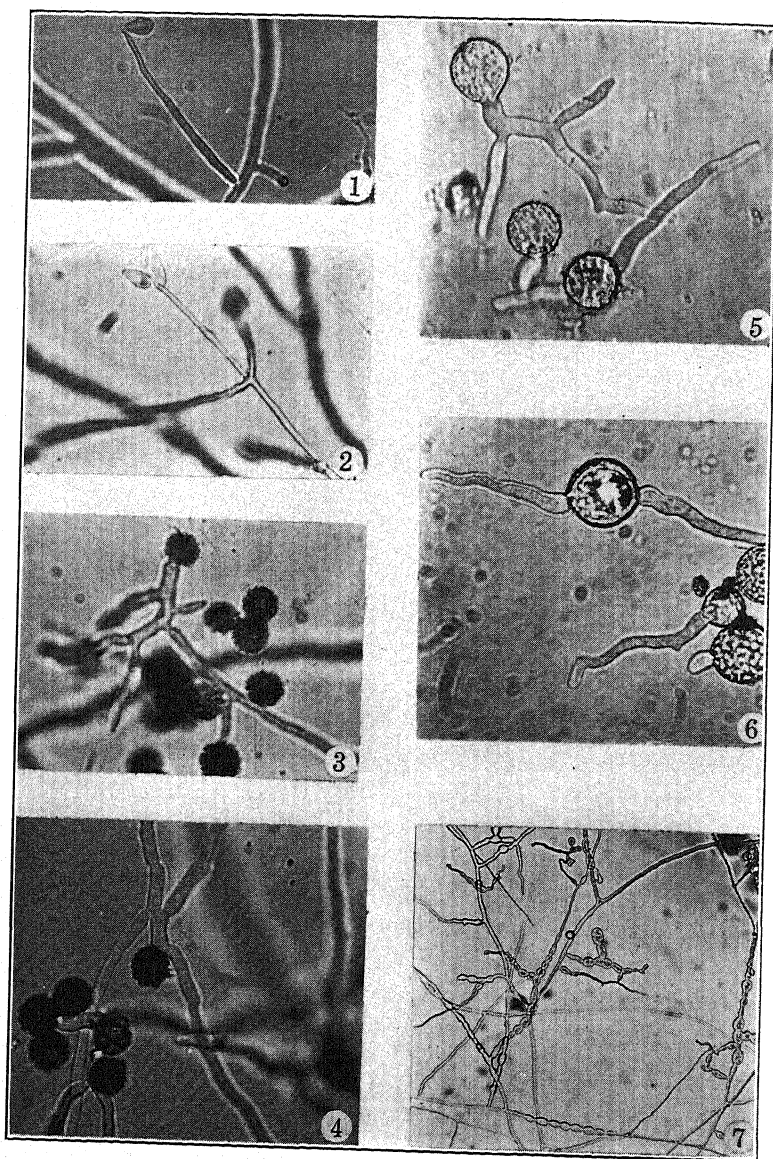


FIG. E. 1-4, *Sepsedonium chrysospermum* (Bull.) Link; 5-7, *Sepsedonium xylogenum* Sacc.

one-celled (the two-celled appearance being due to the enlargement of the subtending cell of the sporophore, see figure *D*: 5), large, ovoid, and tuberculate-ridged structures, subtended by a hyaline, obconic, basal cell (FIG. *C*: 9; *D*: 5). The phialophores, unlike those of the other species in which phialospores are present, are of the *Aspergillus* type (FIG. *C*: 9–10). They are irregularly swollen at the apex or they may form obovate to globose heads about  $10\mu$  in diameter. The phialides (FIG. *C*: 9–10) are short and broad,  $6-9 \times 3\mu$ , and produce phialospores endogenously. The latter are hyaline, oblong, rounded,  $4 \times 2\mu$ , and are abstricted into mucilaginous heads or in chains.

The aleuriospores of *Mycogone perniciosa* are from the beginning two-celled structures and thus are distinct from those genera already considered. The upper cells become densely echinulate while the lower cells remain minutely warted (FIG. *D*: 1). The phialophore is similar to that produced by *Sepedonium* and *Stephanoma*, but the phialospores are more elongate and narrower in *Mycogone* (FIG. *D*: 2).

These last two genera appear to be so obviously different from *Histoplasma* and *Sepedonium* that little more need be said at this point. However, it does seem desirable to point out the general resemblances in the life histories since, because of the fact that they are related to *Sepedonium* through their congeneric perfect stages (*Hypomyces*), they will serve as controls in determining the interrelationships of these forms by future serological studies.

#### DISCUSSION

The organism described as a protozoön by Darling has been variously placed in classification. Its possible relationship to the Endomycetales has been indicated by de Monbreun, but on the evidence available at present, classification in this order seems premature since he did not demonstrate the presence of any ascigerous stage. Because of the presence of tuberculate spores, Hansmann and Schenken have suggested that this organism should be placed in the genus *Sepedonium*. If the manner of spore formation of *Histoplasma* and *Sepedonium* is compared, it is evident that the two genera have much in common since in both cases the



spores are formed as bulbous enlargements of the terminal ends of terminal or lateral branches. However, *Histoplasma* differs from *Sepedonium* in that during its life cycle the former not only produces yeast-like bodies in its parasitic phase but also lacks phialospores during its saphrophytic phase.

The classification of *Histoplasma* has been further confused by Moore as a result of his misinterpretation of the aleuriospores which he considered to be true asci, evidence for which statement is wholly untenable especially since he has presented no cytological evidence of nuclear fusion or of meiotic division and the work of de Monbreun, substantiated by the writer, has shown that the so-called ascospores are merely fatty globules which stain readily with Sudan III, Scharlach R, and osmic acid, and furthermore, may be made to disappear by suitable reagents or by heating.

Therefore, since the ascigerous stage has not been demonstrated and also, since the spores formed in *Histoplasma* are homologous with those of *Sepedonium*, that is, are aleuriospores, it would seem advisable for the present to consider *Histoplasma* as a separate genus in the Fungi Imperfecti that shows a form relation to *Sepedonium*, *Stephanoma*, and the related genera discussed in this paper. It is hoped in a subsequent paper that the actual relationships of these species may be demonstrated and as a result the classification of *Histoplasma* may be determined.

#### SUMMARY

1. *Histoplasma*, *Sepedonium*, *Stephanoma*, *Chlamydomyces* and *Mycogone* have been studied in culture.

2. The life histories and morphological development of these fungi have been compared; the so-called asci of *Histoplasma* have been shown to be aleuriospores.

3. It has been proven by culture methods that *Stephanoma tetracoccum* van Zinderen-Bakker produces a phialospore stage and has been suggested that *S. tetracoccum* is the imperfect stage of *Hypomyces Geoglossi* Ellis & Ev.

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## EXPLANATION OF FIGURES

The drawings were made with the aid of a camera lucida and for the most part from material mounted in lacto-phenol cotton-blue. With but few exceptions, noted in the explanation of the figure, all drawings were made at a magnification of approximately 2150. The present figures are reduced to a magnification of 750. For convenience an absolute scale representing ten microns is included in each figure.

FIG. A. 1-25. *Histoplasma capsulatum* Darling.

1. Portion of aerial mycelium to show arrangement of mature aleuri-spores. Typical growth on 2 per cent sucrose (Merck), 1 per cent Difco Bacto-peptone agar after 7 weeks. 750 X.

2. Optical section of a developing aleuriospore; an abnormal type of development. After 66 hours on 2 per cent Difco proteose peptone broth in a van Tieghem cell. 750 X.

3-4. Cluster of aerial aleuriospores (sessile in 4) in an early stage of development. After 66 hours on 2 per cent Difco proteose peptone broth in a van Tieghem cell. 750 X.

5. Smooth-walled type of aleuriospores developed below surface of agar. After 6 weeks on 4 per cent sucrose (Merck) agar. 750 X.

6-10. Optical sections of small, mature aleuriospores developed below surface of agar. After 7 weeks on sucrose (Merck) agar. Note that in 10 the small spores may be echinulate as well as smooth. 750 X.

11-16. Aleuriospores showing variations in size from the small type, arrested in development, to the large, normal type, all produced on the submerged mycelium. 7 weeks on 4 per cent sucrose (Merck) agar. 750 X.

17-23. Successive stages in development of the tuberculate aleuriospores, all drawings shown in optical section. After 66 hours on 2 per cent Difco proteose peptone broth in a van Tieghem cell. 750 X.

24. Optical section through a cluster of aerial aleuriospores showing their acropetalous development. 750 X.

25. Successive stages in formation of the smooth-walled aleuriospores formed below the surface of agar; after 6 weeks on 4 per cent sucrose (Merck) agar. 750 X.

FIG. B. The photomicrographs were taken from material in van Tieghem cell preparations at a magnification of 600. The present figures are reduced to a magnification of approximately 400.

1-9. *Histoplasma capsulatum* Darling.

1. Early stage in formation of pedicellate aleuriospores on aerial mycelium. After 70 hours on potato maltose broth in a van Tieghem cell.

2. Early stage in formation of a sessile aleuriospore on submerged mycelium. After 70 hours on potato maltose broth in a van Tieghem cell.

3. Early stage in development of cluster of aerial aleuriospores produced acropetally on a short lateral branch. After 66 hours on 2 per cent Difco proteose peptone in a van Tieghem cell.

4. Cluster of mature aerial aleuriospores showing moderately tuberculate wall. After 66 hours on 2 per cent Difco proteose peptone broth in a van Tieghem cell.

5. Germination of aleuriospore showing two germ tubes, both arising at

the same pole of the spore. After 15 hours on 2 per cent Difco proteose peptone in a van Tieghem cell.

6. Germination of aleuriospores showing single germ tubes. After 15 hours on 2 per cent Difco proteose peptone in a van Tieghem cell.

7. Germination of an aleuriospore showing a single germ tube which branches shortly after its emergence from the spore. After 15 hours on 2 per cent Difco proteose peptone broth in a van Tieghem cell.

8. Germination of an aleuriospore showing enlargement of a single germ tube into a globose structure, immediately upon its emergence from the spore, from which arise several hyphae. After 26 hours on potato maltose broth in a van Tieghem cell.

9. Aerial aleuriospores from 7 weeks old culture on 1 per cent Difco Bacto-peptone, 2 per cent sucrose (Merck) agar, showing fat globules stained 12 hrs. with Sudan III. 800 X.

FIG. C. 1-6. *Sepedonium chrysospermum* (Bull.) Link.

1. Cluster of aleuriospores showing spore initials and mature spores. After 2 weeks on potato maltose agar. 645 X.

2-6. Successive stages in the formation of aleuriospores to illustrate the manner of formation of the spines and the close parallel existing between it and that of *Histoplasma capsulatum*. 750 X.

7. *Sepedonium xylogenum* Sacc. Cluster of aleuriospores. After 8 days on potato maltose agar. 750 X.

8. *Stephanoma tetracoccum* van Zinderen-Bakker. Mature aleuriospores and stages in their formation at the end of 6 weeks on potato maltose agar. 750 X.

9-10. *Chlamydomyces palmarum* (Cooke) Mason.

9. Single aleuriospore and phialophore showing phialides and immature spores. From 1 week old culture on potato maltose agar. 750 X.

10. Longitudinal section of phialophore showing phialides and formation of phialospores. 750 X.

FIG. D. 1-2. *Mycogone perniciosa* Magn.

1. Aleuriospores, showing their arrangement and formation. After 8 days on potato maltose agar. 750 X.

2. Single phialophore, showing phialides and phialospores. After 8 days on potato maltose agar. 400 X.

3. *Sepedonium chrysospermum* (Bull.) Link. Single phialophore, showing phialides and phialospores. After 4 weeks on 2 per cent Difco Bacto-peptone broth in a van Tieghem cell. 360 X.

4a and b. *Stephanoma tetracoccum* van Zinderen-Bakker. Two phialospores showing phialides, and a phialospore isolated from *Geoglossum* sp. 360 X.

5. *Chlamydomyces palmarum* (Cooke) Mason. Cluster of aleuriospores. 750 X.

FIG. E. 1-4. *Sepedonium chrysospermum* (Bull.) Link.

1. Tip of phialide showing single phialospore. 46 hours after aleuriospores had been inoculated on 2 per cent Difco Bacto-peptone broth in a van Tieghem cell. 360 X.

2. Tip of phialide showing a cluster of phialospores. 46 hours after aleuriospores had been inoculated on 2 per cent Difco Bacto-peptone broth in a van Tieghem cell. 360 X.

3-4. Germination of aleuriospores. After 46 hours on 2 per cent Difco Bacto-peptone broth in a van Tieghem cell. 360 X.

5-7. *Sepedonium xylogenum* Sacc.

5-6. Germination of aleuriospores. After 12 hours on 2 per cent Difco proteose peptone broth in a van Tieghem cell. 360 X.

7. Bullate bodies produced on submerged mycelium. After 36 hours on 2 per cent Difco proteose peptone broth in a van Tieghem cell. 320 X.

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# A STUDY OF BOTRYOSPHAERIA RIBIS ON WILLOW

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(WITH 19 FIGURES)

## INTRODUCTION

*Botryosphaeria Ribis* was first described in 1911 by Grossenbacher and Duggar (2) as the cause of cane blight of species of *Ribes*. This fungus was not reported to attack other species of plants until 1924, when it was collected on *Aesculus hippocastaneum* L. and *Rosa setipoda* Hemsl. and Nils. (8). Subsequent investigations by Shear, Stevens, and Wilcox (6), Stevens (10), Stevens and Shear (9), Reichert and Hellinger (4), Savastano (5), and Smith (7) have extended the host range to include woody species in nearly a score of families and have shown that the organism has a wide geographic distribution.

Although Shear<sup>1</sup> in 1916 collected *B. Ribis* on willow at Arlington, Virginia, the first account of its occurrence on the genus *Salix* is that of Stevens (10), in 1924, from collections made in four localities in Florida. *B. Ribis* has subsequently been collected on pussy willow, *Salix discolor* Muhl., in Arkansas, Georgia, Mississippi, North Carolina and Virginia. Although the organism is apparently widely prevalent on species of *Salix* throughout the southeastern United States no studies have as yet been made of the morphology and development of *B. Ribis* in connection with willow canker.

## APPEARANCE OF THE DISEASE

The first evidence of infection of willow trees by the fungus is afforded by the presence of occasional blighted twigs and branches. At any time during the growing season, the leaves on an infected

<sup>1</sup> A record of collections of *B. Ribis* on willow in the Office of Mycology and Disease Survey, U. S. Department of Agriculture, was supplied by Dr. H. A. Edson for which courtesy grateful acknowledgment is herewith made.

limb may wilt and become dry, but defoliation does not occur for a considerable period. Blighted twigs are characterized by the presence of elongate depressed lesions which girdle the branches below the dying parts.

On the trunk and larger branches, numerous cankers develop. The bark in cankered areas becomes dry and cracked, and sometimes the wood is exposed in the sharply demarcated cankers which result. Smaller cankers on the trunk are circular in outline, crateriform, and approximately one-quarter to one-half inch in diameter (FIG. 1); as many as a hundred may occur in a one foot-length of trunk. By the anastomosis of several smaller cankers, large ones several inches in length may arise. During the spring and early summer, an exudate attractive to ants accumulates at the surface of the lesions or flows from the cankered areas. The inner bark becomes reddish or purplish in color for a distance of several inches from the margin of the lesions, and short adventitious roots may form along the trunk.

One or more large limbs may die during a single growing season. Within another year or two, the cankers may become so abundant as to completely girdle the trunk, and within three or four years following the initial infection, the entire tree may be killed.

Examination of lesions on willow twigs with a hand lens will disclose the dark fungous stromata protruding from cracks in the outer bark. The peculiar white contents of fructifications characteristic of *B. Ribis* (see Shear, Stevens, and Wilcox (6), *pl. 9, fig. D*) may be seen by making a cut parallel to the surface and removing the bark, revealing the presence of from one to six locules within each stroma.

#### DESCRIPTION OF THE PATHOGEN

Only the pycnidial or *Dothiorella* stage of *B. Ribis* is present in lesions on willow twigs of the current season's growth. On older branches, perithecia may be found as well. Pycnidia and perithecia may be formed either in the same or in separate stromata. In the vicinity of Durham, N. C., both stages may be found at any time throughout the year. Fructifications of *B. Ribis*, fixed in formalin acetic alcohol, sectioned in paraffin to a thickness of 8 to 10 microns, and stained with Haidenhain's iron



FIG. 1. Cankers caused by *B. Ribis* on willow branches. The large canker on the branch at the left is fissured at the margin and near the center. Small circular cankers have fused to make the large one.



alum hematoxylin, were used in making a morphological study of the pathogen.

**PYCNIDIA.**—On the inner wall of the pycnidium (FIG. 2) are thin-walled conidium-bearing cells, or conidiophores, each of which bears a sterigma-like process which projects inward from the pycnidial wall and also toward the ostiole. The conidia are abstricted singly from the apices of the conidiophores and are formed so profusely that, when the bark is wet, they may become aggregated at the opening of the ostiole to form white masses visible macroscopically. The conidia are unicellular, bluntly fusoid, and hyaline. They range in size from  $18-30 \times 4.5-8 \mu$ , averaging  $18-20 \times 5-6 \mu$ .

**SPERMOGONIA.**—Throughout the fall and winter, pycnidium-bearing stromata on willow may also contain locules in which are produced hyaline, oval to elongate microconidia,  $2-3 \times 1 \mu$ . Similar structures were apparently observed on currant canes by Grossenbacher and Duggar (2), in "stromata bearing intact perithecia and often pycnidia." The uncertainty of Grossenbacher and Duggar concerning the nature of these structures may be seen from the following statement: "These *Cytospora*-like pycnidia seem to belong to a fungus that develops on the disintegrating stromata of the *Ribes* fungus; although that point remains uncertain and could not be tested culturally because the spores failed to germinate. Yet it is possible that this only represents a virescence of certain intact portions of old *Botryosphaeria* stromata."

Similar microconidial structures in *Botryosphaeria melanops* (Tul.) Wint. (*Dothidea melanops*) were illustrated many years ago by the Tulasnes (11). Since a considerable number of Ascomycetes are now known to possess spermogonia and spermatia of similar appearance, it seems reasonable to assume that the *Cytospora*-like structures observed by Grossenbacher and Duggar (2) on currant canes and which we have found on willow constitute the spermogonial stage of *B. Ribis*.

**PERITHECIA.**—Very little is known concerning the early stages in the development of the perithecia of *B. Ribis*. The locule is at first constituted of cells with dense protoplasmic contents. These cells later disintegrate, being utilized by the developing asci. Maturation of the asci, which are interspersed with numerous

paraphyses, proceeds centrifugally from the center of the perithecium, only a few of the asci reaching maturity at any given time (FIG. 3).

The thickened apical wall of the ascus is provided with a pore, which functions in the discharge of the ascospores. As the outer

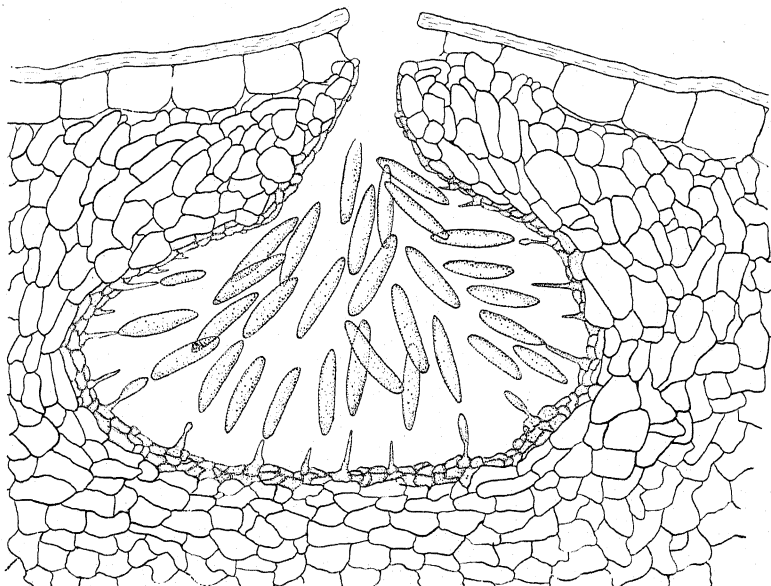


FIG. 2. Stroma in section showing pycnidium, conidiophoral cells and conidia.

ascus wall ruptures at the pore, the inner wall greatly elongates, and extends into the ostiole of the perithecium. Upon discharge of the ascospores, the wall of the ascus collapses, and the process of expulsion is repeated as succeeding groups of asci mature. The asci of *B. Ribis* on willow are broadly clavate to saccate, and measure  $70-90 \times 17-22 \mu$ ; the ascospores are hyaline, measuring  $18-24 \times 6-9 \mu$ .

#### DEVELOPMENT OF CONIDIA AND ASCOSPORES

Although extended studies previously have been made concerning the host range and parasitism of *B. Ribis*, practically no attention has been devoted to the morphology and development of

the fungus since the pioneer work of Grossenbacher and Duggar (2). From specimens collected on willow, the formation of conidia and the development of the ascus and ascospores have been studied by means of paraffin sections of material fixed in formalin

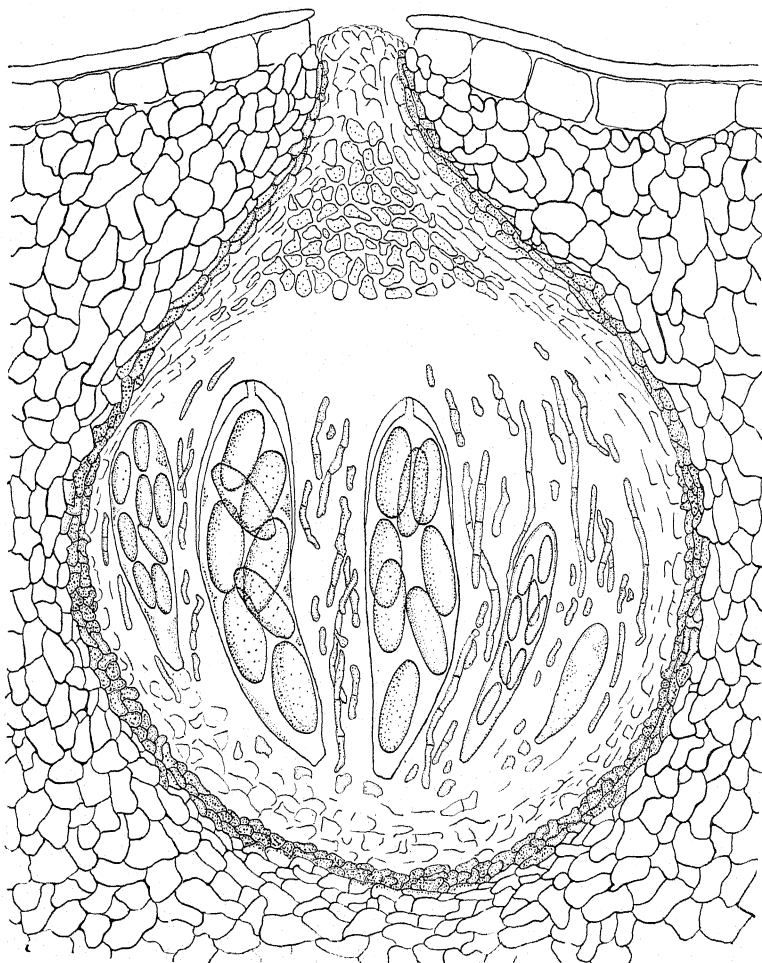


FIG. 3. Perithecial stroma in section with asci in different stages of maturity, and paraphyses.

acetic alcohol and stained with Haidenhain's iron alum hematoxylin.

CONIDIA.—The pycnidium is lined with a layer of thin-walled cells, some of which, herein called conidiophores, are to be con-

cerned with the formation of the conidia. Each conidiophore, which is at first uninucleate, develops an attenuate sterigma-like process (FIG. 15-16). Following a division of the conidiophore nucleus, one of the daughter nuclei remains in the basal portion of the conidiophore, the other migrating into the sterigma (FIG. 17). Then the distal end of the sterigma enlarges, further nuclear divisions occur within it (FIG. 18), and eventually a multinucleate conidium is abstricted (FIG. 19). The mature conidium contains on the average 4 to 6 nuclei. A single nucleus remains within the conidiophore, which may bear other conidia by a repetition of the process just described.

ASCUS AND ASCOSPORES.—Study of the development of the ascus and ascospores of *B. Ribis* was greatly facilitated by the fact that the asci do not mature simultaneously, a single peritheciium containing, at a given time, asci of different ages. Very young asci 20-30  $\mu$  in length will contain a single large primary ascus nucleus (FIG. 4). Development proceeds as in other ascomycetous fungi, two, four, and finally eight free nuclei being formed (FIG. 5-7). When the ascus has attained about half of its final length, free cell formation occurs and eight uninucleate ascospores are delimited (FIG. 8, 9). Each ascospore nucleus then undergoes a series of divisions (FIG. 10-12) producing multinucleate ascospores. The mature ascospore while still within the ascus (FIG. 13, 14) may contain as many as 12 to 16 nuclei.

In order to ascertain the number of nuclei within each hyphal cell, conidia and ascospores were germinated on glass slides in a moist chamber, and the preparations of the germinating spores were stained *in toto* with hematoxylin. It was found by this means that practically the entire content of the spore becomes emptied into the germ tube, and that the germ tube attains a considerable length before cross walls are formed. The mycelium is therefore constituted of multinucleated cells for a period following germination and whatever the nuclear condition when stromata are being formed, the stromatic cells eventually are uninucleate.

#### CULTURAL CHARACTERS OF THE PATHOGEN

Monoconidial and monoascosporic isolations of *B. Ribis* from willow have been made. Monoconidial cultures were obtained by

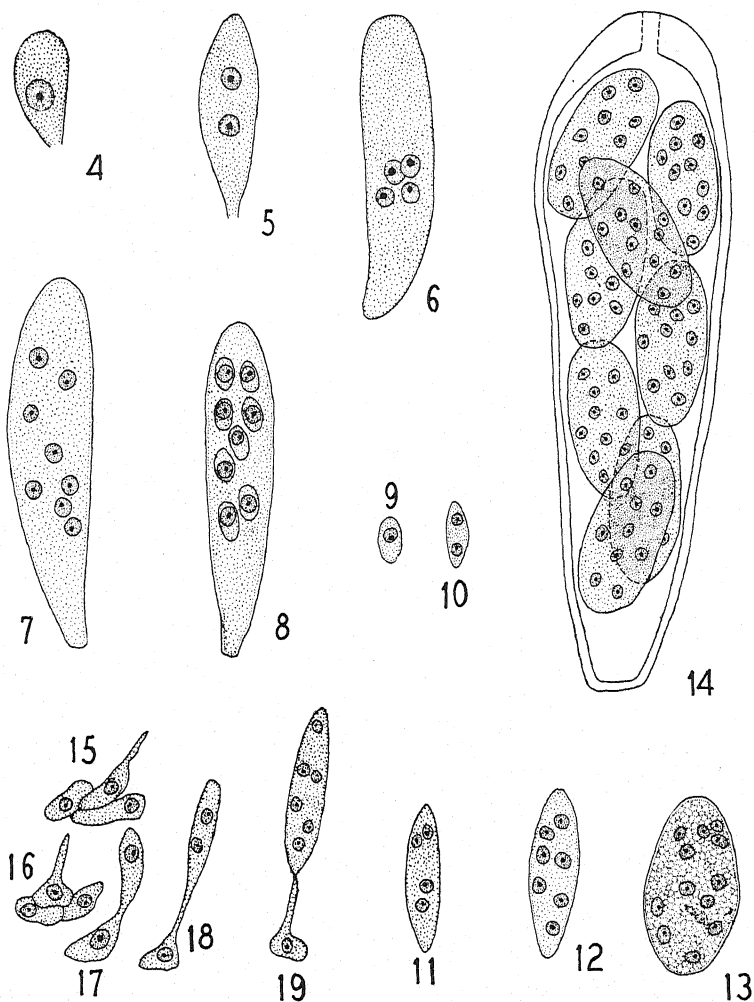


FIG. 4. Young ascus showing primary ascus nucleus; 5, binucleate ascus; 6, ascus in the 4-nucleate stage; 7, ascus containing 8 free nuclei; 8, uninucleate ascospores have been delimited; 9-13, stages in the transformation of uninucleate ascospores to multinucleate ascospores; 14, mature ascus, with pore in thickened apical portion; 15, 16, uninucleate conidiophoral cell of the *Dothiorella* stage and adjacent cells from the inner pycnidial wall; 17-19, stages in the formation and abstriction of conidia of the *Dothiorella* stage, and the formation of multinucleate conidia.

the dilution method, while cultures from single ascospores were initiated by inverting an agar plate over a lesion containing discharging asci. Both conidia and ascospores of *B. Ribis* germinate readily on malt agar or a medium composed of malt agar containing bits of sterilized willow twigs. Germ tubes several times the length of the spore are formed within 3 to 4 hours, and the entire surface of these media in Petri dish cultures is covered with a blackish-gray mycelium within 10 days.

Although Grossenbacher and Duggar (2) failed to induce sporulation in *B. Ribis*, from currant, in cultures upon a variety of media, the production of conidia from isolates from several hosts has been obtained by Stevens and Jenkins (8), Shear, Stevens, and Wilcox (6), and Smith (7). Pycnidial stromata of the *Dothiorella* type bearing an abundance of conidia indistinguishable from those on willow cankers were produced in our cultures derived from either ascospores or conidia.

Zonation occurred in cultures maintained under ordinary laboratory conditions of alternate light and darkness, but failed to occur in cultures grown in continuous total darkness. In addition to this zonation phenomenon, sectoring occurred in a few of the cultures, irrespective of the conditions of illumination. Occasionally, several sectorings occurred in a single culture, and sectors within sectors were produced in several instances. What relation sectoring may bear to the great variability of *B. Ribis* in nature, as shown by its wide host range, is as yet a matter of conjecture.

#### DISCUSSION

In nearly all species of Ascomycetes that have been investigated cytologically, the cells of the vegetative mycelium and of the reproductive structures, with the exception of the antheridia and ascogonia, are uninucleate. For this reason, the occurrence of a multinucleate condition in the mycelium, conidia, and ascospores of *B. Ribis* is of special mycological interest. In *Dipodascus albidus* Lagerh., *Monascus Barkeri* Dang., *Endomyces Magnusii* Ludw., and *Penicillium crustaceum* Link, the mycelium and conidia have been shown by Dangeard (1) to be multinucleate although the ascospores are uninucleate. In *Aspergillus flavus* (L.) Link (*Eurotium herbariorum* Wigg.), the mycelial cells, phialides, conidia, and ascospores are all coenocytic (1).

Although the conidia and ascospores of *B. Ribis* are multinucleate, all of the nuclei of a single conidium or ascospore have the same origin and hence are homocaryotic or genetically similar. In the case of certain other fungi, as *Botrytis cinerea* Pers., it has been demonstrated (Hansen & Smith, 3) that the multinucleate spores are heterocaryotic, this condition having arisen from hyphal anastomoses and nuclear migrations. Hansen and Smith suggest that the variability of *Botrytis cinerea* and perhaps of other fungi may be due to nuclear heterogeneity. Whether any significance can be attached to the multinucleate condition in *Botryosphaeria Ribis* in the light of its adaptability to a wide host range in nature and its great capacity for variation in culture is entirely conjectural.

#### SUMMARY

A disease of willow caused by *Botryosphaeria Ribis* is characterized by the presence of cankers on the twigs, larger branches, and trunk. Successive blighting of the branches eventually results in the death of the tree.

A single stroma of this organism on willow may simultaneously bear conidia, microconidia and ascospores. The microconidia are probably spermatia. Cultures derived from conidia are similar to those originating from ascospores, and from both, the *Dothiorella* stage may be produced.

The development of the conidia, asci and ascospores of *B. Ribis* has been studied cytologically. The conidia are multinucleate but are borne by uninucleate conidiophoral cells. The development of the nuclei within the ascus is like that of other Ascomycetes. The ascospores are uninucleate when delimited but become multinucleate as they mature. For a period following germination the hyphal cells also are multinucleate.

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## A NOTE ON THE OCCURRENCE OF MARASMIUS PYRINUS

VERA K. CHARLES

(WITH 1 FIGURE)

A fungus of rare occurrence or at least one rarely collected was recently submitted to the Division of Mycology and Disease Survey of the Bureau of Plant Industry for determination. The fungus occurred on the fruit of apple, and was so small, only about 1 mm. in diameter, that it suggested a species of *Stilbum*. However with the aid of a hand lens, it was discovered to be an agaric. The collection was received from A. B. Groves, Winchester, Va., with the information that he had observed it several times before, and that it always seemed to follow arsenical spray injury. In the present case, the fungus developed on a definite spot which had resulted from the use of an arsenical spray.

A study of the material showed the fungus to be a species of *Marasmius*, *Marasmius pyrinus* described by Ellis.<sup>1</sup> The type material occurred on leaves of *Pyrus communis*, but the species has been reported on several different hosts. The Mycological Collections contain the following material:

A specimen of Ellis, N. Am. Fungi 401 evidently part of the type dated June 1880.

A second specimen of Ellis on old *Lactuca*, bearing the date 1899. This latter specimen was evidently first determined as *Marasmius* sp., and the specific name was later added to the label. This seems to be the case as the two words, the generic and specific names, are separated, and the ink is different. The specimen on *Lactuca* was given to the Mycological Collections by Dr. C. L. Shear, who had purchased certain remainders of the Ellis Herbarium. The Mycological Collections also contain specimens determined as *Marasmius pyrinus* on cankered apple bark; the cankers were probably due to bacterial blight. This material was

<sup>1</sup> Ellis, J. B. New species of North American fungi. Bull. Torrey Club 8: 64. 1881.

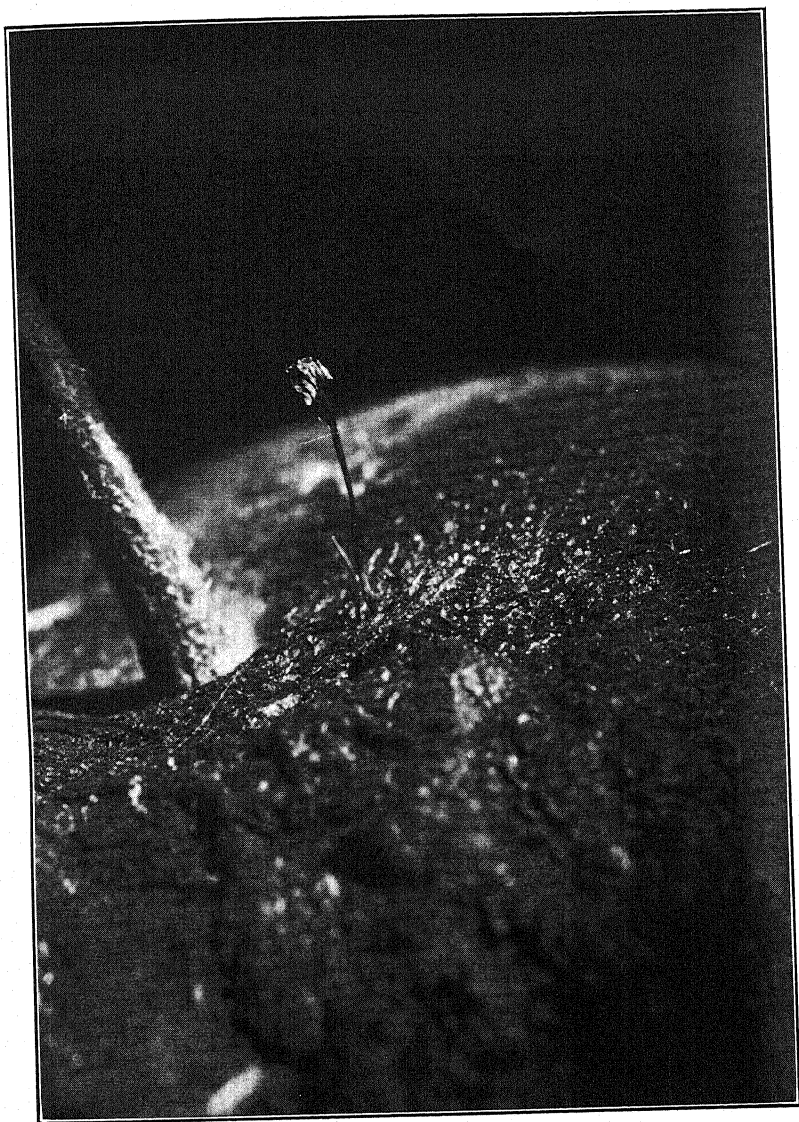


FIG. 1. *Marasmius pyrinus* on the fruit of apple,  $\times 6$ .

collected at Rockville, Md., in 1920 by L. M. Hutchins and referred to the Office of Mycology for determination. It is typical except in the size of the pileus which exceeds the measurements given by Ellis for this species, being 2-2.5 mm. in diameter in-

stead of 1-1.5 as given in the original description of this species by Ellis.

Another specimen contained in the Mycological Collections was collected and determined by G. W. Carver, of the Tuskegee Institute, Aug. 23, 1930. This material is on *Ligustrum* sp., and is more typical in size, but lighter in color than the collections on apple.

Pennington<sup>2</sup> in his treatment of *Marasmius* suggests that *M. pyrinus* Ellis may be synonymous with *M. capillipes* described by Saccardo<sup>3</sup> in 1876 on *Pyrus communis*. Probably Pennington did not have the type or adequate material for examination and comparison necessary to make this identity certain. The absence of good material for comparison is also the difficulty in the present study. The Mycological Collections do not contain a type specimen of *Marasmius capillipes*. Furthermore, a Saccardo specimen of this species on leaves of *Fraxinus ornus* Sacc., *Mycotheca italica* No. 2, published in 1897, unfortunately shows no trace of the fungus. In view of this situation it would seem best to retain Ellis' name for the fungus as it occurs in the United States.

Although this species is extremely minute, the characters noted in Ellis' description particularly the rugoso-sulcate pileus, due to the spiny cells and visible by the aid of a hand lens, renders the species fairly easy of recognition. The accompanying illustration of the fungus on the apple near the stem shows this condition.

BUREAU OF PLANT INDUSTRY,  
WASHINGTON, D. C.

<sup>2</sup> Pennington, L. H. N. Am. Flora 9: 281. 1915.

<sup>3</sup> Saccardo, P. A. Fungi veneti novi vel critici Ser. V. Nuovo Giorn. Bot. Ital. 8: 162. 1876.

## NOTES AND BRIEF ARTICLES

List VI of "Fungus Specimens Available for Exchange" has been issued under date of August 1, 1938, by the Division of Mycology and Disease Survey, of the Bureau of Plant Industry, Washington, D. C. This list is a revision of and supersedes previous lists. A copy will be sent to any mycologist or mycological institution interested in the exchange of fungus material.—JOHN A. STEVENSON.

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Motions dealing with Nomenclature for consideration by the VIIth International Botanical Congress, Stockholm 1940, should be sent before July 1, 1939, to the Rapporteur general, Dr. T. A. Sprague, The Herbarium, Royal Botanic Gardens, Kew, Surrey, England.

Motions must be presented in the form of additional articles, or amendments, to the International Rules. They should be drafted as briefly as possible. At least 100 printed copies must be presented.—JOHN A. NANNFELDT.

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### CANTHARELLUS MULTIPLEX AGAIN

In the May-June number of MYCOLOGIA for 1937 and again in the July-August number for 1938 (pp. 286 and 372, respectively) there appeared short articles on the finding of *Cantharellus multiplex* Underwood. The first of these articles detailed its collection in two localities in Quebec; the second relates to its discovery in Middle Boulder Canyon, Colorado. The authors of both of these articles have overlooked Kauffman's published notes and photo of this species (Papers Mich. Acad. Sci., Arts, Let. 5: 124. pl. V. 1925). Kauffman infers that he at that time had already collected it in the Rocky Mountains of Wyoming and Colorado, and in the Cascade Mountains of Washington and Oregon. He remarks on its similarity to *Cantharellus clavatus* and concludes that it is only "a very extreme growth condition" of that species. There would seem to be no warrant for transferring the species



MYCOLOGICAL SOCIETY OF AMERICA, SUMMER FORAY, AUGUST 24-27, DUCHESNAY, QUEBEC.

to the genus *Craterellus* as was done by the author of one of the above-cited papers.—L. O. OVERHOLTS.

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## MYCOLOGICAL SOCIETY OF AMERICA

### REPORT ON THE 1938 FORAY

(WITH 1 FIGURE)

The 1938 Summer Foray of the Mycological Society of America was held at Dushesnay, Quebec, August 23–27, at the Forest Rangers School. Over fifty persons attended. Adequate laboratory facilities were supplied for studying and drying specimens and a new dormitory was rushed to completion affording comfortable quarters. The plans of the foray were well arranged by Dr. Rene Pomerleau. Trips to points of mycological interest were arranged for each morning. The afternoons were utilized for studying and discussing specimens or individual collecting. Excellent collecting occurred in the immediate vicinity.

On Tuesday evening the Honorable J. Bourque, Minister of Lands and Forests welcomed the Society. On Wednesday evening colored slides of fungi were shown by Robert Hagelstein and E. B. Mains, and Henry A. C. Jackson exhibited his excellent paintings of agarics. On Friday evening films illustrating the wild life and picturesque localities of Quebec were shown.

Due to frequent rains throughout August fungi were abundant. Arrivals on Tuesday drove through a steady downpour. On Wednesday the weather cleared and ideal mycological conditions prevailed. This together with easy accessibility and variety of habitats resulted in an accumulation of specimens that taxed all the drying facilities. A number of rare and interesting species were found.

A business meeting was held on Thursday evening at which President L. O. Overholts presided. Invitations were received to hold the 1939 foray in Florida and in Louisiana. Other possibilities were discussed with the White Mountains and Rhode Island being favored. Due to the small amount of published information in regard to the mycological flora of Quebec, it was voted to

publish a complete list of the fungi collected during the foray. A committee consisting of L. O. Overholts, Rene Pomerleau and E. B. Mains was appointed to supervise the preparation of the list. After voting that the thanks of the Society be extended to the Honorable J. Bourque, Director Henri Roy, Dr. Rene Pomerleau and the local committee for the excellent facilities, the meeting adjourned.

The foray ended on Saturday with a trip to the Laurentian National Park. At Camp Mercier, the group was served a delicious lunch with brook trout direct from the lake.—E. B. MAINS.

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Members who have not yet paid their dues are requested to send them to Dr. J. N. Couch, Department of Botany, University of North Carolina, Chapel Hill, North Carolina. By cooperating in this manner they will greatly assist the Secretary-Treasurer and will avoid undue delay in receiving MYCOLOGIA.—D. H. LINDER.

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The Summer Foray of the Mycological Society of America will be held in the Great Smoky Mountains during the latter part of August. The exact time and the location of headquarters will be announced at a later date. However, it would greatly facilitate arrangements if all those who think they may attend would be so kind as to notify David H. Linder, The Farlow Herbarium, 20 Divinity Ave., Cambridge, Mass.—D. H. LINDER.

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#### LATIN DIAGNOSES

Since the adoption, by the International Commission on Nomenclature, of the rule requiring that the descriptions of all new species and genera be accompanied by Latin diagnoses, most journals, including MYCOLOGIA, have required their contributors to comply with this regulation. If this is not done, such species and genera are not legally published, and if later translated into Latin, the date and place of publication will be to the work containing such Latin diagnoses. Without attempting to discuss the merits of

this requirement, failure to comply would at least result in much confusion.

This requirement, on the part of the Mycological Society, as a prerequisite for publication in *MYCOLOGIA*, has aroused such a storm of protest from some members of the Society that the matter has been reconsidered, the Society voting to leave the question in the hands of the Editorial Board. After careful consideration the Board has decided to make this a recommendation rather than a requirement. This does not mean that the Board shall not still continue to request such diagnoses. In fact, if they are not furnished by the author, it will be necessary for the Editor to solicit these in each individual case, which will involve not only extra work but delay in the publication of papers. If you wish to avoid such delay, send *brief* Latin diagnoses with all descriptions of new species or genera when manuscript is submitted for publication.—FRED J. SEAVER, EDITOR.

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#### MYCOLOGIA ENDOWMENT FUND

During the year 1938, the restricted Mycologia Endowment Fund has been increased by the addition of one thousand dollars (\$1000), bringing the total to six thousand dollars (\$6000). All of this has been built up either through private donation for that purpose, or through money secured from the sale of the early volumes (1-24). It has been the purpose of the Managing Editor to pay all the current expenses of *MYCOLOGIA* out of the current receipts, leaving the money from the sale of the early volumes to be added to this fund. Few mycologists are able to assist directly in the building up of such an endowment. However, any member of the Society may use his influence to place the early volumes of *MYCOLOGIA* where they are needed, and in this way indirectly contribute to the building up of this fund. It is intended that the interest on this endowment will eventually be used to promote special features in the journal which cannot be taken care of out of the current income. To this end your cooperation is solicited.—FRED J. SEAVER, MANAGING EDITOR.



SAWADA'S DISCOVERY OF *ACHLYA FLAGELLATA* AS A  
PARASITE OF FISH

In a previous paper (Tiffney and Wolf, 1937), it was reported that the water mold *Achlya flagellata* Coker is capable of infecting the newt, *Triturus viridescens*, as well as the fishes *Lebistes reticulatus*, *Fundulus heteroclitus*, and *Salvelinus fontinalis*. The author wishes to correct a most unfortunate error in this paper; namely, the statement that *A. flagellata* had never previously been shown to parasitize fishes.

Sawada (1912) published entirely in Japanese the results of a study of a disease of paddy rice seedlings in Formosa, caused by a fungus which he called *Achlya prolifera* (Nees) de Bary. Incidental to the phytopathological portion of this investigation, Sawada (1912, 1919) reported that this fungus was found to occur under natural conditions on living goldfish (*Carassius auratus* var.) and the Japanese fighting fish. Healthy goldfish and fighting fish, as well as Medaka (*Oryzias latipes*) and Gusai-chi, when placed in water containing cultures of the fungus, became covered with the cottony mycelium, and were killed within a week. Sawada (1912) published an excellent photograph of a fighting fish killed by the fungus (Pl. IV, fig. 1) showing tufts of mycelium on the head, gills, fins, and tail. A complete diagnosis and several carefully drawn plates of the fungus are also included in Sawada's paper.

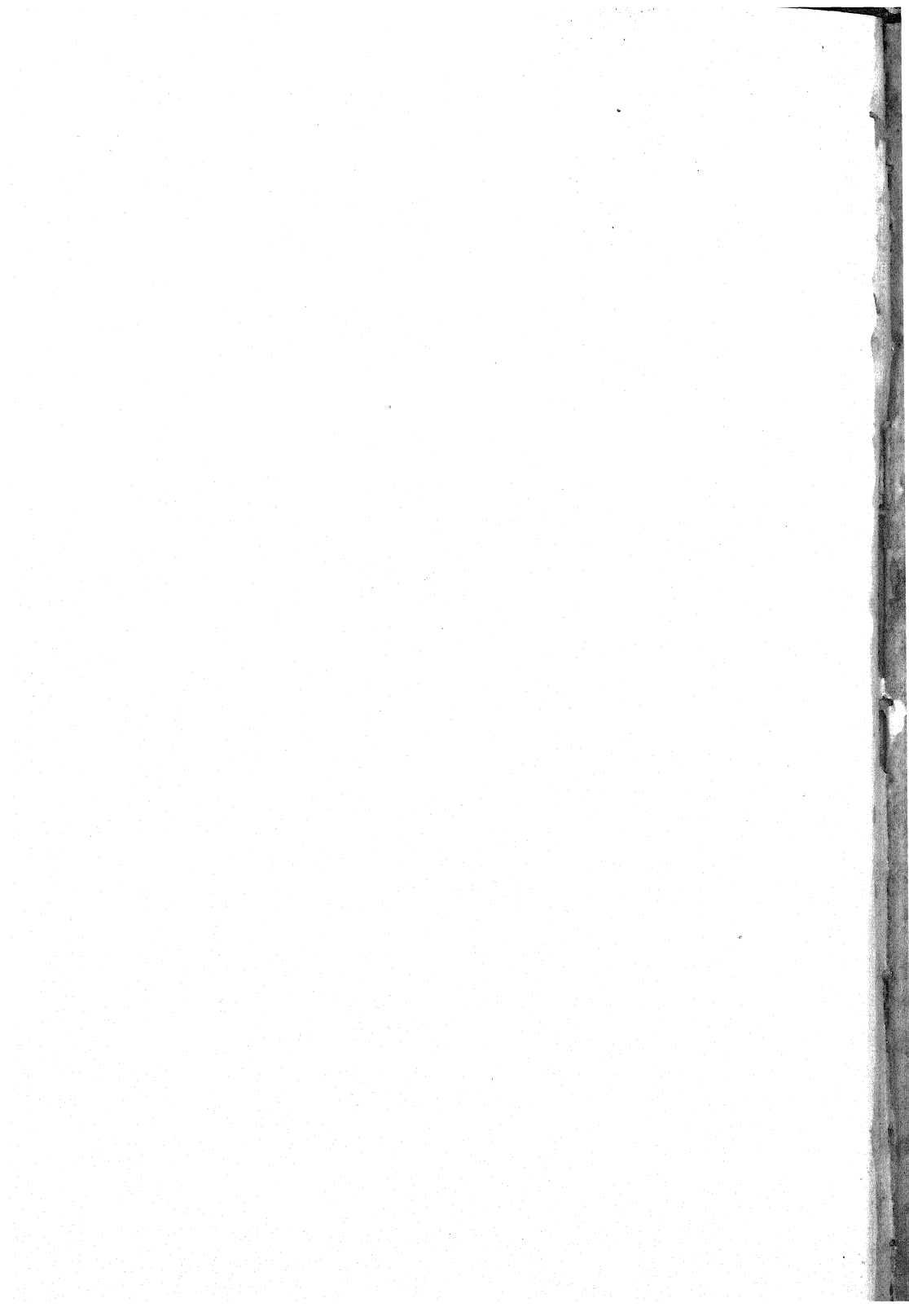
According to Nagai (1931), Cejp (1934), and Coker and Matthews (1937), the fungus which Sawada called *A. prolifera* (Nees) de Bary is not that species, but is probably *A. flagellata* Coker. The writer has compared Sawada's description and plates with those of *A. flagellata*, and is also of the opinion that the two fungi are identical. It would appear, therefore, that Sawada must be credited with the discovery of the fact that *A. flagellata* is capable of parasitizing fishes, even though this species was not described for more than a decade after the publication of his observations.

This brief note was written during the tenure of a National Research Fellowship under the direction of Prof. Wm. H. Weston, Jr., to whom the author is indebted for the opportunity of studying an authorized abridged translation of Sawada's paper.

FRED T. WOLF.

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# MYCOLOGIA

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## NEW OR NOTEWORTHY FUNGI FROM PANAMA AND COLOMBIA. III

G. W. MARTIN

(WITH 18 FIGURES)

*SCLEROCYSTIS COCCOGENA* (Pat.) v. Höhn.

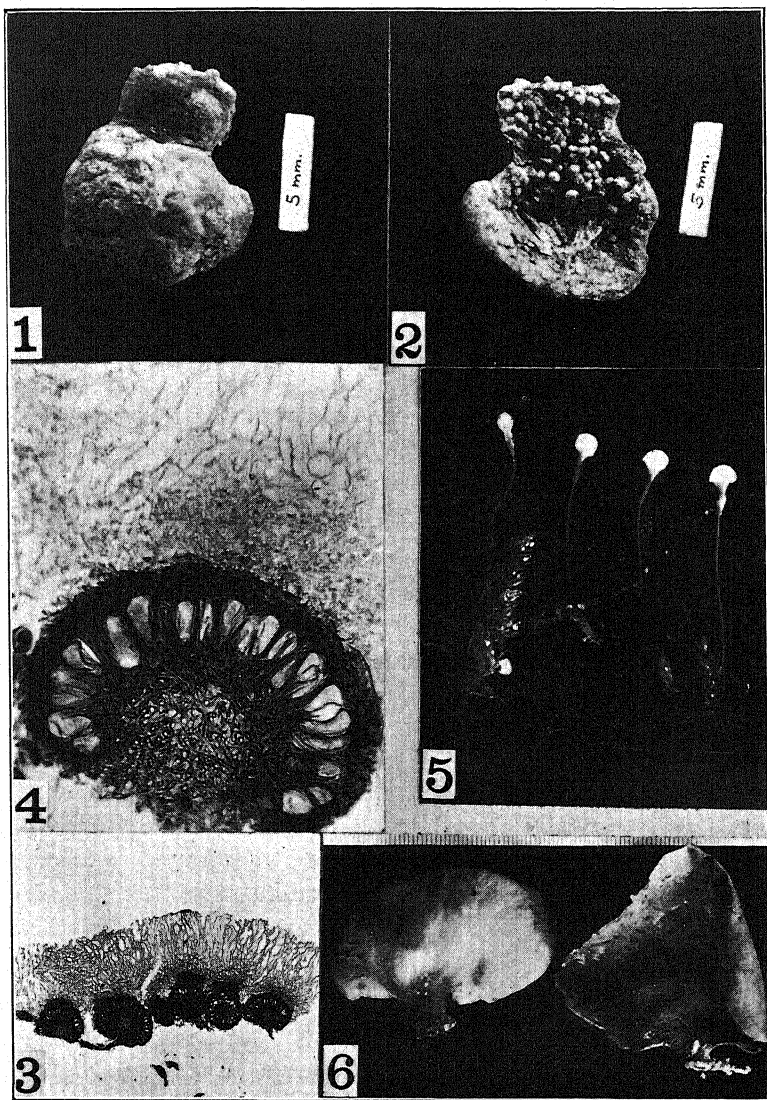
This species, heretofore known only from Martinique, was the second of two species included by Patouillard (Bull. Soc. Myc. Fr. 18: 183. 1902) in his genus *Ackermannia*, the first being *A. Dussii*, from Martinique and Guadeloupe. Patouillard placed *Ackermannia* in the Ascomycetes near *Onygena*, regarding the long spores as asci. He noted, however, the resemblance to *Endogone* of which he suggested *Ackermannia* might be the perfect stage. Von Höhnelt (Frag. 474. Sitzungsber. Akad. Wien Abt. 1. 119: 398. 1910) showed that the species of *Ackermannia* were congeneric with the earlier *Sclerocystis* Berk. & Br., based on an inadequately described species from Ceylon, and that they belonged in the Endogonaceae. Von Höhnelt gives a brief review of the other pertinent literature, which need not be repeated here, and recognizes four species as included in the genus, one of which, *S. pubescens*, was later removed from it by Thaxter (Proc. Am. Acad. 57: 291-341. 1922).

A single collection from Colombia (Hacienda Cincinnati above Santa Marta, Dept. Magdalena, 1250-1500 m. Aug. 22, 1935. G. W. M. 3609) is the second record of the occurrence of this species and permits certain additions to the published descriptions.

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The stroma occurred on a dead twig, and was pure white when collected except for brownish stains where handled. It resembled nothing so much as a thick, fleshy cocoon enclosing a cluster of insect eggs. In drying, it became detached from the substratum and the color changed to a yellowish-brown, but the appearance remained essentially the same (FIGS. 1, 2). When dry, it measured  $11 \times 8.5$  mm. The photographs were taken after a small piece had been cut from one end. A portion of this was soaked in lactic acid, imbedded in paraffin and sectioned and stained. Median sections through the sporocarps show the enormous, radially arranged spores arising from a columella-like center (FIG. 4) looking almost exactly like Thaxter's beautiful drawing of *S. Dussii* (his *pl.* 4, *fig.* 83). The spores, as measured in the sections, range from  $63$  to  $89 \mu$  in length and from  $28$  to  $45 \mu$  in width. Patouillard gives the dimensions as  $\pm 100 \times 60 \mu$ , but it is evident that he did not see the septum just below the junction of the inflated portion and the stalk; at least these are not shown in his drawing of the same structures in *S. Dussii*. Thaxter says "about  $100 \times 40\text{--}50 \mu$ ." It seems probable that some allowance must be made for measurements made from sections, which can in few instances be strictly longitudinal and which may have been affected by the treatment to which they had been subjected. On the other hand, the spherical or oval chlamydospores mentioned by both authors as characteristic of the species, are larger than the dimensions,  $25\text{--}30 \mu$ , given by Patouillard, ten globose ones taken at random ranging from  $26$  to  $39 \mu$  in diameter. It is doubtful whether such differences are significant in this group, and in other respects the agreement is so striking as to leave little doubt of the correctness of the determination.

In summarizing the differences between *S. Dussii* and *S. coccogena*, Thaxter refers to "the apparent absence of a lysigenous pseudotissue of large, thin-walled hyphal segments" in the latter species. Thaxter's statement, expressed with characteristic caution, is undoubtedly to be attributed to the very scanty material available to him for examination, described as "a very small fragment." As reference to the illustration (FIG. 3) will show, this tissue is present in *S. coccogena* and is entirely comparable with that of *S. Dussii*.



FIGS. 1-4. *Sclerocystis coccogena*; 5, *Jola javensis*; 6, *Mycobonia flava*.

Several chlamydospores were noted in which the contents were separated into small, uniform aggregations of protoplasm, suggesting, but not satisfactorily demonstrating, that they were being transformed into sporangia.

***Tulasnella sphaerospora* sp. nov.**

Late et interrupte effusa, tenuis, ceraceis, lilaceis, in sicco pallescente; probasidiis globosis, 11–14  $\mu$  diam.; epibasidiis globosis demum ovatis, apiculatis; basidiosporis globosis, (8–)10–12  $\mu$  diam.

Thin, tenuous, waxy, lilaceous-pink when fresh, drying to a dingy, whitish pruinose coating on the substratum and not recovering its color when soaked; hyphae short-celled, rather irregular, without clamp connections, 3–6  $\mu$  in diameter; probasidia globose with a short stalk, 11–14  $\mu$  in diameter, becoming somewhat ovate and giving rise to 2, 3 or 4 probasidia, these at first globose, then elongate-ovate, the body merging gradually into the short-subulate sterigma; basidiospores globose, apiculate, (8–)10–12  $\mu$  in diameter, germinating by repetiton.

Panamá: Prov. Chiriquí. Valley of upper Rio Chiriquí Viejo, 1600–1800 m. July 11, 1935. Encrusting bark, mosses and lichens on an upper branch of a freshly felled tree at an estimated height of fifty feet above ground. G. W. M. 2750, type. In Herb. State Univ. Iowa and Missouri Bot. Gard.

The massive, globose basidia of this species (FIGS. 7, 8) mark it off from all hitherto known species of *Tulasnella* except very large examples of *T. violea*, from which it is at once separated by the large, consistently globose spores (FIG. 10). When collected, the bright pinkish-lavendar color made it rather conspicuous. When dry, it forms an inconspicuous whitish mold on the substratum, recovering its waxy consistency but not its color when soaked.

**TULASNELLA VIOLEA (Quél.) Bourd. & Galz.**

Colombia. Dept. Magdalena. Hacienda Cincinnati, 1250–1500 m. Aug. 12, 1935. G. W. M. 3334.

Although the cool, moist climate of the tropical mountains would seem to be ideal for the *Tulasnellas*, this and the preceding species constitute the only representatives of the genus among my collections. It is not likely they were overlooked, since I was on

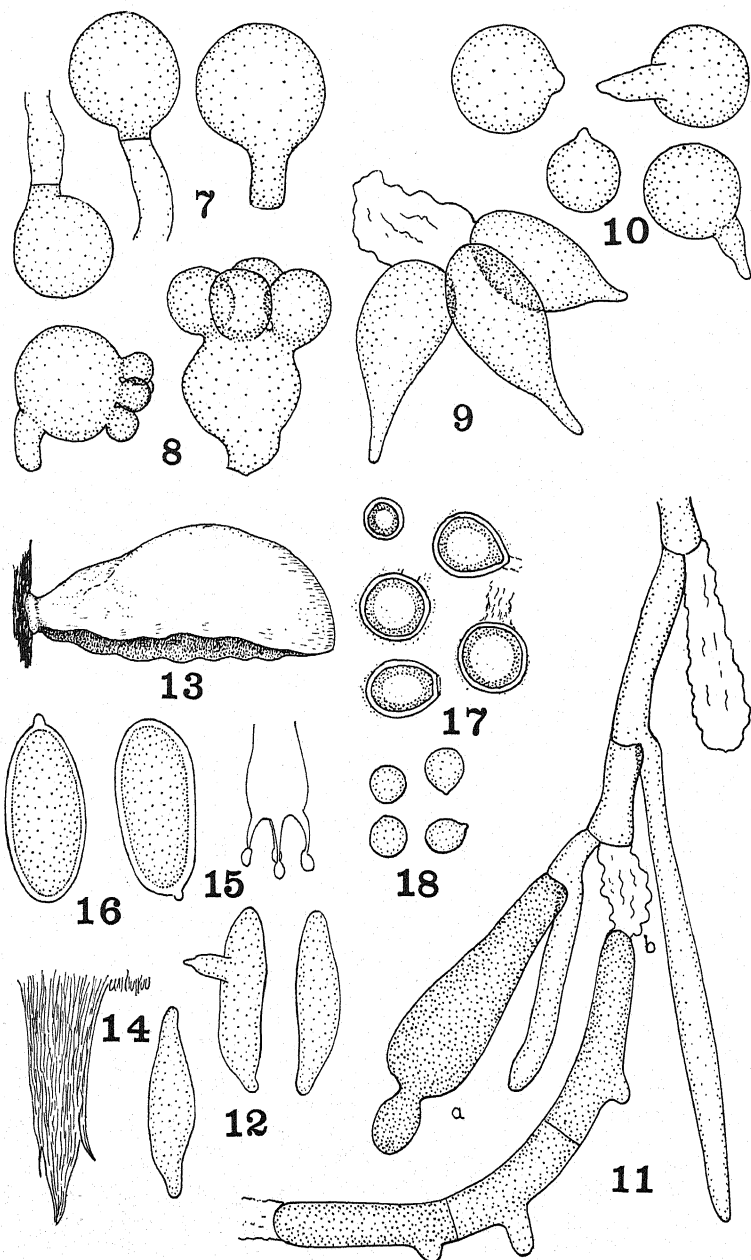
the watch for them and both collections were recognized as *Tulasnella* in the field. It is possible that collections made at the beginning of the rainy season would show them to be more abundant.

*JOLA JAVENSIS* Pat.

The genus *Jola* was established by Möller (Protobasidiomyceten 22. 1895) on the single species *J. Hookeriarum* from Brazil, which he described fully and illustrated. Shortly afterward Patouillard (Bull. Soc. Myc. Fr. 13: 97. 1897) described two additional species, of which only one, *J. javensis*, from Java, need here concern us. In the same year he published an amplified description of this species, with illustrations (Bull. Jard. Bot. Buitenzorg Supp. 1: 119. 1897). Gäumann found Patouillard's species to be extremely abundant in the mountains of Java, and not only added to the description, but studied the fungus cytologically (Ann. Myc. 20: 272-289. 1922).

According to Patouillard, *javensis* differs from *Hookeriarum* in its longer and more clavate probasidia, its curved epibasidia and its smaller spores, the dimensions of which he gives as  $15-20 \times 3-4 \mu$  as against Möller's figures of  $28-36 \times 6 \mu$  for *Hookeriarum*. To these differences Gäumann adds that the fructifications of *javensis* are consistently globose and gelatinous while those of *Hookeriarum* are less regular in shape and the basidia are not immersed in a gelatinous matrix. With reference to the latter point, Möller does, indeed, say that while the fructifications, when moist, appear to be imbedded in a thin jelly, under the microscope no gelatinous matrix can be seen. His habit sketches (1. c. pl. 4, f. a) and the rest of his description suggest strongly that this is a matter of definition, just as in the case of his genus *Stypella*, where, as I have previously pointed out (Univ. Iowa Stud. Nat. Hist. 16: 143-149. 1934), his statements as to the nature of its fructification have led, as I believe, to misunderstanding. Gäumann gives the spore size as  $12-21 \times 3-5 \mu$ , which is in substantial agreement with the dimensions given by Patouillard. His illustrations show probasidia that are consistently elongate-clavate, but the epibasidia are both straight and curved, hence this supposed distinction between the two species cannot be valid. All three authors agree that the hypobasidium is emptied of its contents





FIGS. 7-10. *Tulasnella sphaerospora*; 11, 12, *Jola javensis*; 13-16, *Myco-bonia flava*; 17, 18, *Stereum flabellatum*.

when the epibasidium is fully developed and that the latter is cut off by a septum, but all show the empty hypobasidium as plump, with rounded contours, a condition difficult to explain in a thin-walled cell. Furthermore, while Möller gives  $90\ \mu$  as the maximum length of the epibasidium in *Hookeriarum* as against Patouillard's maximum of  $55\ \mu$  for *javensis*, the probasidia of *Hookeriarum*, so far as may be judged from the illustrations, are proportionately much smaller. Since the size of the epibasidia is in such cases largely determined by the volume of the probasidia, this again suggests an error in Möller's illustrations.

The specimens here reported were found on patches of a moss in western Panamá on the banks of the Rio Chiriquí Viejo, Prov. Chiriquí, above 1600 m., in July, 1935 (G. W. M. 2272, 2273, 2274, 2339). Dr. A. J. Sharp, of the University of Tennessee, has kindly identified the host as a species of *Raphidorrhynchium*. They differ in certain minor respects from the descriptions of both *J. Hookeriarum* and *J. javensis*. I find ovate, clavate and cylindrical probasidia in the same fructification, but the clavate type is decidedly the most abundant. They are extremely variable in size, ranging from  $14\text{--}35\ \mu$  in length and  $5.5\text{--}7.5\ \mu$  in diameter. The epibasidium develops as a cylindrical filament, separated from the hypobasidium by a marked constriction (FIG. 11a) much as shown in Möller's and Patouillard's figures but less apparent in those of Gäumann. It may be straight or curved, and may finally attain  $60\ \mu$  in length, occasionally slightly more, and  $5\text{--}6\ \mu$  in diameter. In the formation of the epibasidium, the hypobasidium is entirely emptied of its contents and cut off by a septum, after which it promptly collapses (FIG. 11b), not remaining plump as shown in the illustrations of all three of the authors cited. The spores are mostly  $20\text{--}22\ \mu$  in length, rarely somewhat shorter or longer, and  $4.5\text{--}5\ \mu$  in width (FIG. 12). They germinate by repetition, as shown by Möller and Gäumann, except that in all the instances observed the secondary epibasidium was developed laterally.

The fructifications themselves are mainly globose (FIG. 5), but not uncommonly irregular, and while they were mostly on the capsules a number occurred on the stalks of the sporophores. They are certainly gelatinous but when mounted for microscopic

observation, no gelatinous matrix such as is clearly visible in *Auricularia*, *Tremella* and *Exidia* can be seen.

Except for spore size, I cannot regard the published distinctions between *Jola Hookeriarum* and *J. javensis* as very significant, and even spore size tends to be much more variable in the Protobasidiomycetes than in most other fungi. While my specimens are somewhat intermediate even in this respect, I assign them to Patouillard's species for the time being on the basis of the predominantly clavate probasidia and the small spores, but with a strong suspicion that that species will eventually be reduced to a synonym of *Hookeriarum*.

#### STEREUM FLABELLATUM Pat.

Originally described from Guadeloupe, this species was reported in Standley's first list of fungi from Barro Colorado Island (Smithsonian Misc. Coll. 78 (8): 7. 1927). Patouillard's original description (Bull. Soc. Myc. Fr. 16: 179. 1900) refers to it as whitish when living, livid and pellucid when dry. Burt's description (Ann. Missouri Bot. Gard. 7: 111. 1920) is mainly a translation of Patouillard's. Neither mentions the spores.

The form which I refer to this species is abundant on Barro Colorado Island, where large logs are frequently covered with the delicate pilei. When young, they are pure white, becoming somewhat dingy when older, and drying livid and translucent, with dark-brown or bay stems. A few basidiospores were found, none attached to sterigmata, but evidently belonging to the species. These are smooth, hyaline, globose or subglobose, and 4-5  $\mu$  in diameter (FIG. 18). In numerous sections, basidia were entirely lacking, but the pileus, 300-450  $\mu$  in total thickness, had the lower fourth more or less transformed into a layer of spherical or broadly ovate chlamydospores (FIG. 17), variable in size but mostly 4-8  $\mu$  in diameter or in the longer dimension. These are often attached to shrivelled hyphae and surrounded by an indistinct gelatinous sheath. The wall is thick, 0.7-1  $\mu$ , and most of the interior is occupied by a large vacuole. It is possible, of course, that these represent the spores of a parasitic fungus, but their appearance and manner of development is such as to render it improbable.

## MYCOBONIA FLAVA (Berk.) Pat.

Although this species occurs from the southern United States to the Argentine and has been collected a number of times it is still inadequately known. Originally described from Jamaica as a *Peziza* by Swartz in 1788, it was transferred by Berkeley to *Hydnum* (Ann. Mag. Nat. Hist. I. 10: 380. 1842). Some years later Berkeley described *H. brunneoleucum* Berk. & Curt. (Trans. Linn. Soc. 22: 129. 1859), from Venezuela, as a closely allied species, differing in the paler color of the hymenium and the divided "bristles."

Patouillard (Bull. Soc. Myc. Fr. 8: 49. 1892) in establishing the genus *Bonia* on a resupinate species, *B. papyrina*, from Tonkin, remarked incidentally that *Hydnum flavum* should be referred to this genus. According to Patouillard himself, *Bonia* Pat. proves to be a homonym of *Bonia* Balansa, and judging from the description, his *B. papyrina* may be either a *Veluticeps* or a *Heterochaete*. At any rate, two years later he established the genus *Mycobonia* (Bull. Soc. Myc. Fr. 10: 77. 1894), basing it on *H. flavum*. Still later (Bull. Soc. Myc. Fr. 16: 180-181. 1900), in reporting both species from Gaudeloupe, he published the combination *M. brunneoleuca*, applying this name to the stipitate forms and retaining the sessile forms in *M. flava*. He notes that *brunneoleuca* may attain a diameter of 15 cm. Banker (Mem. Torrey Club 12: 179. 1906), unaware of Patouillard's treatment and of the sterile nature of the teeth, included these forms in the Hydnaceae, establishing for them the genus *Grandinioides* and regarding both as phases of a single species. He properly emphasizes the subgelatinous nature of the pileus, but his suggestion that *brunneoleuca* "appears to be only a poorly developed form of *G. flavum*," while warranted by Berkeley's descriptions, is at variance with Patouillard's comment. Lloyd (Myc. Writ. 4. Letter 56: 11. 1915) also regarded both forms as included in a single species. Hennings (In E. & P. Nat. Pfl. I. 1\*\*: 123. 1897) retains the species in *Bonia* and this disposition is maintained by Killermann in the second edition. Burt (Ann. Missouri Bot. Gard. 6: 262. 1919) recognizes both species, describing *flavum* as sessile, with a buff hymenium, and *brunneoleucum* as short-stipitate, with a pallid

hymenium, thus utilizing both Berkeley's and Patouillard's distinguishing characters.

The specimens was common in July, 1935, in western Panamá in the valley of the upper Rio Chiriquí Viejo above 1600 m., and is represented by seven collections. The specimens vary from sessile with a constricted base, to short-stipitate, the stipe commonly dark, but sometimes concolorous with the bright tan of the upper side of the pileus. The hymenium is a duller and paler tan, and might well be described as whitish in some of the older sporophores. When fresh it was purplish tan, and under a lens it could be seen that the purplish color was due to the numerous purple pegs protruding from the pale tan hymenial surface. The purplish tint largely disappears in dried specimens. The largest basidiocarp collected measured 7 cm. in the stem axis and 9 cm. across. The shape in every case was much more concave and shell-like than is suggested by Hennings' figure (Engler and Prantl I. 1\*\*: 122 f. 68G), which looks as though it had been drawn from a flattened specimen. Berkeley's later characterization of *H. brunneoleucum* (Jour. Linn. Soc. Bot. 10: 324. 1868), "pileo tenui galeaeformis" is very vivid and entirely applicable to these specimens as they occurred in nature. The habit sketch (FIG. 13) redrawn from a field sketch, attempts to bring this out.

In young sporophores the pegs are regularly conical; later they become fimbriate (FIG. 14) and, when dry, justify Berkeley's reference to "granuliform processes." The sporophores, when soaked, are very tough-gelatinous, and difficult to section. The hymenium is extremely dense and contains, in addition to the somewhat sparsely spaced basidia, densely refractive clavate and fusiform bodies, some of which are probably young basidia and others paraphyses, and subgelatinous hairs similar to those which make up the pegs. The spores are smooth and noticeably thick-walled (FIG. 16), and, according to my measurements, when fully mature,  $21-22 \times 8.5-10 \mu$ , considerably above the dimensions Burt gives.

On the basis of the fairly ample material at my disposal, I am convinced that Banker and Lloyd were justified in combining the two supposed species. Slight variations in the color of the hymenium in dried, as in fresh specimens, may be explained as due

largely to the stage of development of the sporophore at the time of collection. The presence or absence of a stipe seems to be determined by the accident of position, and especially by the size of the substratum, forms growing on small twigs, as was the specimen first studied by Berkeley, showing a greater tendency to be sessile than applanate sporophores growing laterally on large trunks.

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#### EXPLANATION OF FIGURES

FIGS. 1-4. *Sclerocystis coccigena*. 1, outer surface of stroma,  $\times 3\frac{1}{8}$ ; 2, inner surface freed from substratum, showing sporocarps,  $\times 3\frac{1}{8}$ ; 3, section of portion of stroma, showing sporocarps and pseudotissue of large hyphae which comprise the stromatic wall,  $\times 20$ ; 4, section of single sporocarp, showing inner portion of peridium and chlamydospore (at left),  $\times 107$ .

FIG. 5. *Jola javensis*, four fructifications on moss capsules,  $\times 3\frac{1}{8}$ .

FIG. 6. *Mycobonia flava*, upper surface at left, lower at right,  $\times \frac{3}{4}$ .

FIGS. 7-10. *Tulasnella sphaerospora*. 7, three probasidia; 8, epibasidia developing; 9, basidium with three epibasidia, hypobasidium empty and collapsed; 10, four basidiospores, two germinating by repetition. All  $\times 1200$ .

FIGS. 11-12. *Jola javensis*. 11, tip of basidium-bearing branch, showing clavate probasidium with epibasidium starting to develop (a), mature epibasidium with collapsed hypobasidium (b), the apical cell empty and collapsed, the three lower cells beginning to develop lateral branches, above, a collapsed hypobasidium from which the epibasidium has fallen away; 12, three basidiospores, the middle one germinating by repetition. Both  $\times 1200$ .

FIGS. 13-16. *Mycobonia flava*. 13, habit sketch, redrawn from field sketch of fresh specimen,  $\times 1$ ; 14, hyphal peg,  $\times 250$ ; 15, tip of basidium,  $\times 555$ ; 16, two basidiospores,  $\times 1200$ .

FIGS. 17-18. *Stereum flabellatum*. 17, five chlamydospores; 18, four basidiospores. Both  $\times 1200$ .

FIGS. 7-12 and 14-18 drawn with aid of camera lucida and reproduced at approximately the magnifications indicated.

## COPRINUS URTICAECOLA ON STEMS OF MARQUIS WHEAT<sup>1</sup>

W. F. HANNA

(WITH 2 FIGURES)

In the spring of 1934 vernalized seed of Marquis wheat that had been inoculated with loose smut, *Ustilago Tritici*, was sown in rows in the field at Winnipeg for the purpose of determining the effect of the vernalization treatment on loose smut development. In July, when the rows were being examined for smut infection, it was observed that fruit-bodies of a small agaric were developing on the stems of two of the plants, close to the ground level. At the time this observation was made the plants were still green, and those to which the fungi were attached appeared to be as healthy as any of the others.

When the two plants referred to were examined later in the laboratory it was found that the fruit-bodies were attached to the leaf sheaths at a point about half an inch above the crown. The leaf sheaths themselves were dead, although the stems which they enclosed were still green. From one plant two, and from the other eight fruit-bodies developed. Their appearance is shown in figure 2, A-D.

The fruit-bodies produced on Marquis wheat, as well as those appearing subsequently in pure culture, answered to the description of *Coprinus urticaecola*<sup>3</sup> (Berk. & Br.) Buller. This fungus, originally placed in the genus *Psathyra* in 1861, was collected in 1912 on sticks, dead leaves, and haulms of *Holcus lanatus* at Kew, England, by Prof. Buller (1 and 2), who transferred it to the genus *Coprinus*.

<sup>1</sup> Contribution No. 561, Botany and Plant Pathology, Science Service, Department of Agriculture, Ottawa, Canada (continuing the Series of the former Division of Botany).

<sup>2</sup> Senior Plant Pathologist, Dominion Rust Research Laboratory, Winnipeg, Manitoba.

<sup>3</sup> The preferred spelling according to the International Rules of Botanical Nomenclature is *Coprinus urticicola*.

In July, 1937, *C. urticaecola* was found again at Winnipeg, growing profusely on decaying nettle stems. Buller (1, 2) states that the fruit-bodies are "chalky white," but it is inferred from his account that the specimens on which his description was based developed on sticks that had been placed in a damp chamber. Under such conditions it was found that fruit-bodies developing at Winnipeg were usually white, whereas those growing in a less humid atmosphere were frequently ornamented with brown scales (FIG. 2, A, E).

In 1881 Karsten (3) described *C. phaeosporus*, found growing at the roots of decaying grass. This species was later described by Lange (5) from specimens collected at Hjallesø, Denmark, on a "loamy rubbish-heap among germinating grass seed." Judging from the description and illustrations given in Lange's published account, and in his correspondence with the writer, it is considered highly probable that *C. phaeosporus* and *C. urticaecola* are identical.

*C. Brassicae* Peck, described and illustrated in 1889 (8), is probably also identical with *C. urticaecola*. This species was found by Peck on decaying stems of cabbage and was considered by him to be related to *C. phaeosporus* Karst., *C. Friesii* Quél., and *C. tigrinellus* Boudier. It was later collected on corn stalks by Murrill (7) who gave a complete description of it with illustrations. Kauffman (4) also described *C. Brassicae* from specimens gathered on "corn stalks, weed stalks, and dead grass."

Species of the genus *Coprinus* are usually saprophytic and, so far as the writer is aware, there is no published account of their occurrence in association with living wheat plants. Other species of agarics have frequently been found on the stems of cereals but the exact nature of their relationship with their hosts, whether parasitic, saprophytic, or symbiotic, has not been ascertained.

Both Tehon (10) and Young (11) reported a species of *Marasmius* on cereals in the United States, and some of the plants from which the fruit-bodies developed showed symptoms of injury. A species closely resembling *M. insititius*<sup>4</sup> was found by Mains (6) on dying stems and leaves of *Festuca capillata*, but whether or not the mycelium of the agaric was responsible for the condition of the plants was not determined. More recently Sprague (9) pub-

<sup>4</sup> Vide Mains (6) *Marasmius instititiosus* Fries.



lished a brief account of the occurrence of species of *Pholiota* and *Naucoria* on the crowns of oats, barley, and wheat in Oregon. He found that Basidiomycetous mycelium was sometimes present in the cortical cells of the roots, but its presence there did not seem to be associated with any injurious effects. On the contrary, when

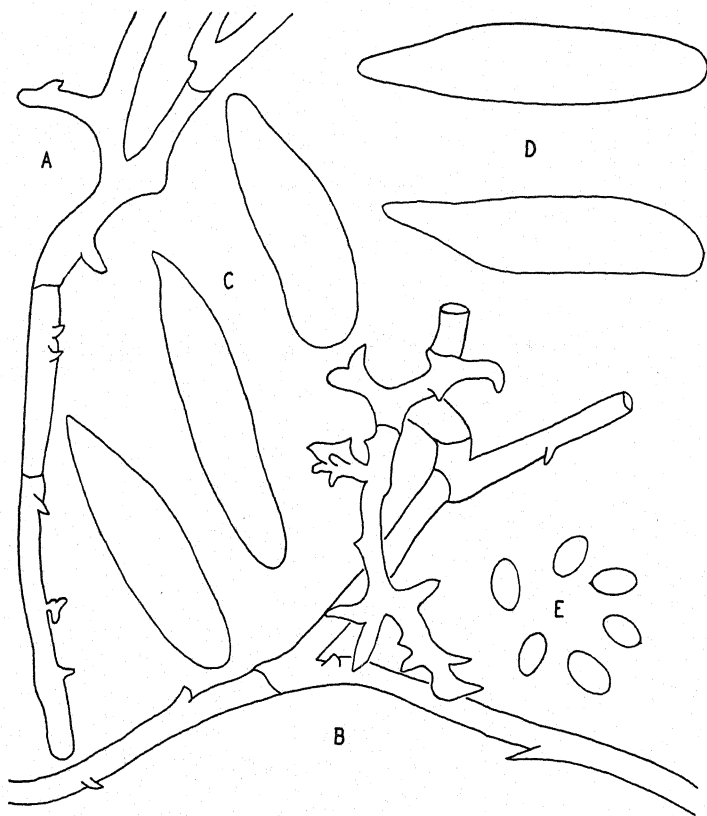


FIG. 1. *Coprinus urticaecola*: A, B, hyphae from surface of pileus,  $\times 700$ ; C, three cystidia from the edges of the gills,  $\times 700$ ; D, two cystidia from between the gills,  $\times 700$ ; E, spores,  $\times 800$ .

pure cultures made from certain of the agarics referred to were introduced into soil in which cereals were growing the inoculated plants developed more vigorously than the uninoculated ones.

Plants of Marquis wheat growing in pots in the greenhouse were inoculated with a diploid culture of *Coprinus urticaecola* by placing about the stems at soil level pieces of agar from fresh cultures, and

covering them with a little soil. When inoculated, some of the plants were still in the seedling stage and others were just beginning to produce heads. Although the plants were kept under observation for nearly four months no fruit-bodies appeared either on the stems or on the soil.

Fruit-bodies of *C. urticaecola* were produced by diploid cultures of the mycelium growing on the following substrata: (1) Sterilized soil and horse-dung. (2) Sterilized soil and old wheat stems. (3) Sterilized horse-dung. Fruit-bodies arising from cultures growing on sterilized horse-dung alone usually failed to develop completely and discharge spores. Good fruit-bodies were secured, however, by growing the diploid mycelium on sterilized horse-dung until the latter was converted into pure-culture spawn, and transferring the spawn to a pot nearly filled with unsterilized soil. A thin layer of soil was then dusted over the spawn and it was moistened and covered with a glass dish. Normal fruit-bodies usually appeared on the surface of the soil in about three weeks (FIG. 2, E).

Freshly collected spores of *C. urticaecola* when placed on potato-dextrose agar at laboratory temperature began to germinate in about four hours. The mycelium also grew well on this medium. Spores collected on glass slides and stored for a year at 10° C. still showed about 50 per cent germination, but spores kept for two years under these conditions were no longer viable.

*C. urticaecola* is heterothallic, and when two monosporous mycelia of opposite sex are allowed to intermingle they give rise to a diploid mycelium bearing clamp connections. Sometimes cultures of opposite sex display an aversion to one another and the diploid mycelium appears as a fan-shaped sector growing out from the margin of the colonies near where they meet. The monosporous mycelia derived from a single fruit-body, when paired together in all possible ways, fall into two sexual groups. This is illustrated in tables 1 and 2. The (+) sign indicates that the mating in question has resulted in the production of diploid mycelium bearing clamp connections; the (—) sign indicates that the two mycelia have failed to react with each other.

Four dark-brown sclerotia developed in a diploid culture of *C. urticaecola* that had been kept for six months at 10° C. on a slant

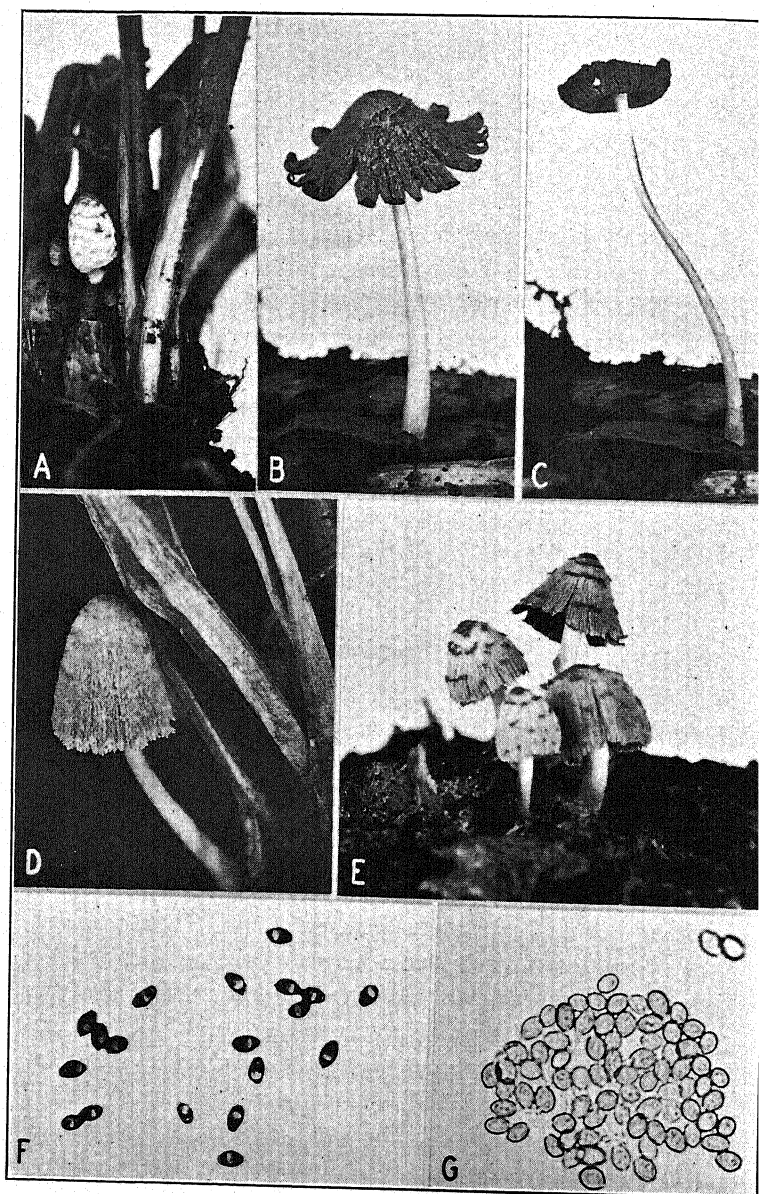


FIG. 2. *Coprinus urticaecola*: A-D, wild fruit-bodies growing on stems of Marquis wheat,  $\times 1\frac{1}{2}$ ; E, fruit-bodies produced in pure culture by two monosporous mycelia of opposite sex growing on sterilized horse-dung,  $\times 1\frac{1}{2}$ ; F, photomicrograph of dry spores collected on a glass slide,  $\times 435$ ; G, photomicrograph of spores mounted in water,  $\times 435$ .

TABLE I

ALL POSSIBLE PAIRINGS OF SEVEN MONOSPOROUS MYCELIA OF *Coprinus urticaecola* DERIVED FROM SPORES OF A SINGLE FRUIT-BODY

	1	6	7	2	3	4	5
1	—	—	—	+	+	+	+
6	—	—	—	+	+	+	+
7	—	—	—	+	+	+	+
2	+	+	+	—	—	—	—
3	+	+	+	—	—	—	—
4	+	+	+	—	—	—	—
5	+	+	+	—	—	—	—

TABLE 2

ALL POSSIBLE PAIRINGS OF TEN MONOSPOROUS MYCELIA OF *Coprinus urticaecola* DERIVED FROM SPORES OF A SINGLE FRUIT-BODY

	8	10	11	13	15	9	14	16	17	18
8	—	—	—	—	—	+	+	+	+	+
10	—	—	—	—	—	+	+	+	+	+
11	—	—	—	—	—	+	+	+	+	+
13	—	—	—	—	—	+	+	+	+	+
15	—	—	—	—	—	+	+	+	+	+
9	+	+	+	+	+	—	—	—	—	—
14	+	+	+	+	+	—	—	—	—	—
16	+	+	+	+	+	—	—	—	—	—
17	+	+	+	+	+	—	—	—	—	—
18	+	+	+	+	+	—	—	—	—	—

of potato-dextrose agar. The culture in question had been made by combining monosporous mycelia 3 and 6 (Table 1). Sections were cut through the largest of the four sclerotia, which was about 3 mm. in diameter, and they were examined under the microscope. The interior of the sclerotium was white, and composed of compact hyphae made up of short, thick, irregularly shaped cells.

After an examination of both wild and cultivated fruit-bodies of *C. urticaecola*, and a study of pure cultures, the following description of the species was prepared:

*Pileus* before expansion campanulate, sometimes completely white, but usually ornamented towards the apex with brown scales; on expansion becoming conical, from 10 to 30 mm. in diameter, finally umbonate, with margin split and recurved; surface of the pileus covered with a detachable felty layer consisting of pale-brown much-branched hyphae (FIG. 1, *A, B*). *Gills* thin, crowded, chocolate-coloured; cystidia abundant on the edges of the gills and bridging the interlamellar spaces (FIG. 1, *C, D*), up to  $115 \times 12 \mu$ ; basidia 4-spored. *Stem* from 20 to 60 mm. in length and from 1 to 2 mm. in diameter, white, hollow, smooth above, slightly squamulose towards the base, attenuated upwards. *Spores* chocolate-coloured in the mass, elliptical, mostly  $7.5 \times 5 \mu$ .

Fruit-bodies gregarious; on decaying nettle stems, and on the basal leaf sheaths of wheat plants. The species is heterothallic and bisexual. The diploid hyphae bear clamp connections. Small sclerotia appeared in a diploid culture growing on potato-dextrose agar.

#### SUMMARY

1. *Coprinus urticaecola* (Berk. & Br.) Buller was found at Winnipeg in 1934 on Marquis wheat. The fruit-bodies were attached near the ground level to leaf sheaths of green plants. In 1937 the species was collected again on decaying nettle stems. It is considered to be identical with *C. Brassicae* Peck, and *C. phaeosporus* Karst. *sensu* Lange.

2. Spore germination and growth of the mycelium occurred readily on potato-dextrose agar. The species fruited on a number of sterile media, but fruit-bodies failed to appear when wheat plants growing in the greenhouse were inoculated with pure cultures of the mycelium.

3. *C. urticaecola* is heterothallic and bisexual. The diploid mycelium bears clamp connections. Small sclerotia were formed on one of the diploid cultures growing on potato-dextrose agar. The species is described and illustrated.

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## LEAFSPOT OF ASH AND PHYLLOSTICTA VIRIDIS

FREDERICK A. WOLF

(WITH 14 FIGURES)

A leafspot disease whose causal fungus is commonly identified as *Phyllosticta viridis* Ellis & Kellerm. occurs on ashes within the area comprising the Duke Forest. The disease has been noted here on white ash, *Fraxinus americana* L., red ash, *F. pennsylvanica* Marsh., and green ash, *F. pennsylvanica* Marsh. var. *lanceolata* (Borkh.) Sarg. (*F. viridis* L.). Seaver (7), from collections in the herbarium of The New York Botanical Garden, recorded *P. viridis* from Connecticut, Illinois, Kansas, Louisiana, Nebraska, New York, and South Dakota, and therefore it is presumed to be widespread east of the Rocky Mountains. Since a detailed study of the life history and development of the pathogen has not been made previously the investigations herein recounted were undertaken.

*Appearance of affected leaves.* Trees of all ages were subjected to this *Phyllosticta* leafspot. Examination of the leaves toward the end of the summer reveals that the lower leaf surface is occupied by widely dispersed, black structures, the fructifications of the fungus. These structures may occur in patches or be more or less uniformly distributed over the entire lower leaf surface. When leaves are viewed from the upper side, during August, there may be no apparent discoloration of tissues or, at most, the leaves may be only slightly less green than normal. As the season advances however, indefinite-margined, pale green spots appear that gradually increase in size, and by mid-September large necrotic areas 0.5–1.5 cm. across have developed (FIG. 1). Meanwhile the black structures will have increased in number to such an extent as densely to occupy the necrotic spots, and defoliation will have begun. Large trees, all of whose foliage was affected, have been observed to be completely defoliated 4 to 6 weeks before killing frosts occurred.

*Identity of the pathogen.* Examination of the black fungous structures, after maceration in water on a glass slide, shows that they may be identified as the fructifications of *Phyllosticta viridis*. Ellis and Kellerman (2), in 1889, described this fungus from specimens collected in Rocks County, Kansas. My identification of the organism has been confirmed by comparison with type specimens<sup>1</sup> among the collections in the herbarium of the Office

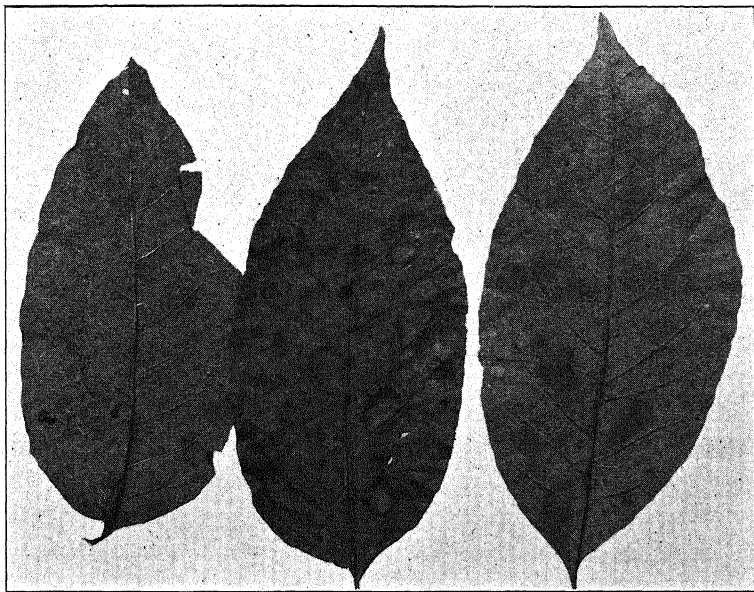


FIG. 1. Ash leaflets affected with the so-called *Phyllosticta* leaf spot; the outer ones, viewed from the lower surface, the middle ones from above. Note the widely distributed black stromata on the two outer leaflets.

of Mycology and Disease Survey, U. S. Department of Agriculture.

Since certain species of *Phyllosticta* are known to possess an ascogenous stage, decaying affected ash leaves were examined from time to time throughout the autumn and winter in search of such a stage. By the middle of March leaves bearing mature perithecia were gathered. The location and distribution of the perithecia (FIG. 2) was noted to be like that of the *Phyllosticta* stage,

<sup>1</sup> Comparison of specimens was made by Dr. W. W. Diehl for which courtesy acknowledgment is herewith made.



and furthermore the structure of these perithecia showed that they belonged to the genus *Mycosphaerella* (*Sphaerella*). Comparison of these collections with other species of *Mycosphaerella*<sup>2</sup> on ash showed them to be identical specifically with *Mycosphaerella fraxinicola* (Schw.) House (4). This stage was first described as *Sphaeria fraxinicola* by de Schweinitz (6) in 1831, from collections made near Bethlehem, Pa. His description was emended by Cooke (1), in 1883, who examined specimens on white ash collected near Darien, Ga., and gave the fungus the name *Sphaerella fraxinicola* (Schw.) (5).

*Structure of the fungus.* Knowledge of the microscopic anatomy of the organism was gained by use of paraffine sections of leaves bearing fructifications. Formalin acetic alcohol was used as a fixing solution, and the sections, cut 5 to 8  $\mu$  thick, were stained with Haidenhain's iron alum hematoxylin. Sections of infected leaves, collected near the middle of August, showed that the black fungous structures that had been presumed to be pycnidia are in reality stromata, each containing one to three locules. Moreover, these locules are of two types, spermogonial and carpogonial, both types sometimes occurring within the same stroma.

*Spermogonia.* The peripheral portions of the stromata are composed of thick-walled cells, devoid of stainable content. The outer wall (FIG. 4) is much thickened. In young spermogonia the locules are loosely filled with thin-walled, deeply staining spermatiferous cells, arranged in chains.

Spermatial formation is initiated near the center of the locule and proceeds centrifugally. Each cell appears to function as a spermatium mother cell and produces four spermatia in the same manner as does *Sphaerella bolleana* Higgins (3). The spermatia are liberated *seriatim* from the apex of a sterigma formed on each cell (FIG. 6). Then the mother cell walls disintegrate, their residue contributing to a mucilaginous matrix that swells in the presence of moisture and causes the spermatia to ooze to the leaf surface. The ostiolar outlet through which the spermatia escape, is developed concurrently with the formation of the first spermatia.

<sup>2</sup> Dr. D. H. Linder, Farlow Herbarium, Harvard University sent me specimens of this fungus collected in Ohio, in 1882, by W. A. Kellerman and determined by J. B. Ellis. This kindness is gratefully acknowledged.

Mature spermogonia (FIG. 4) may appear to be multilocular, as indicated by the several streams of spermatial ooze converging at the ostiolum. This appearance is produced because of the fact that the formation of spermatia does not involve all cells centrifugally at the same rate, chains of spermatiferous cells remaining as partitions.

*Perithecia*. Perithecial development is initiated coincidentally with that of the spermogonia. By the time that spermatia are beginning to be discharged, conspicuous deeply staining carpogonia

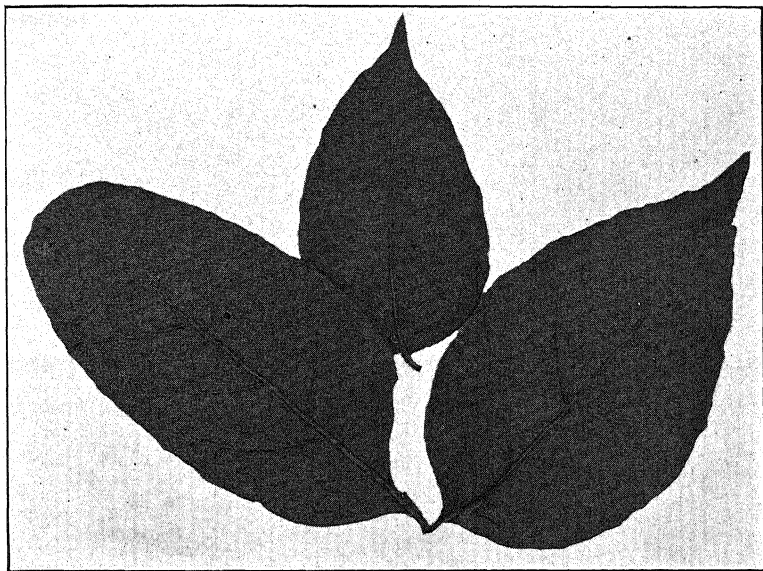


FIG. 2. Perithecial stage of *Mycosphaerella fraxinicola* on ash leaflets.

have become differentiated within the perithecial initials (FIG. 3). From one to four septate carpogonia occur within each locule. The coiled basal portion or ascogonium is enlarged (FIG. 5), and the filamentous portion or trichogyne courses tortuously to the exterior. Each of the several cells composing a carpogonium is at one time uninucleate but it has not been possible to trace the nuclear transformations and structural modifications that eventually lead to the formation of asci. It has been impossible to ascertain moreover, whether all of the carpogonia function or

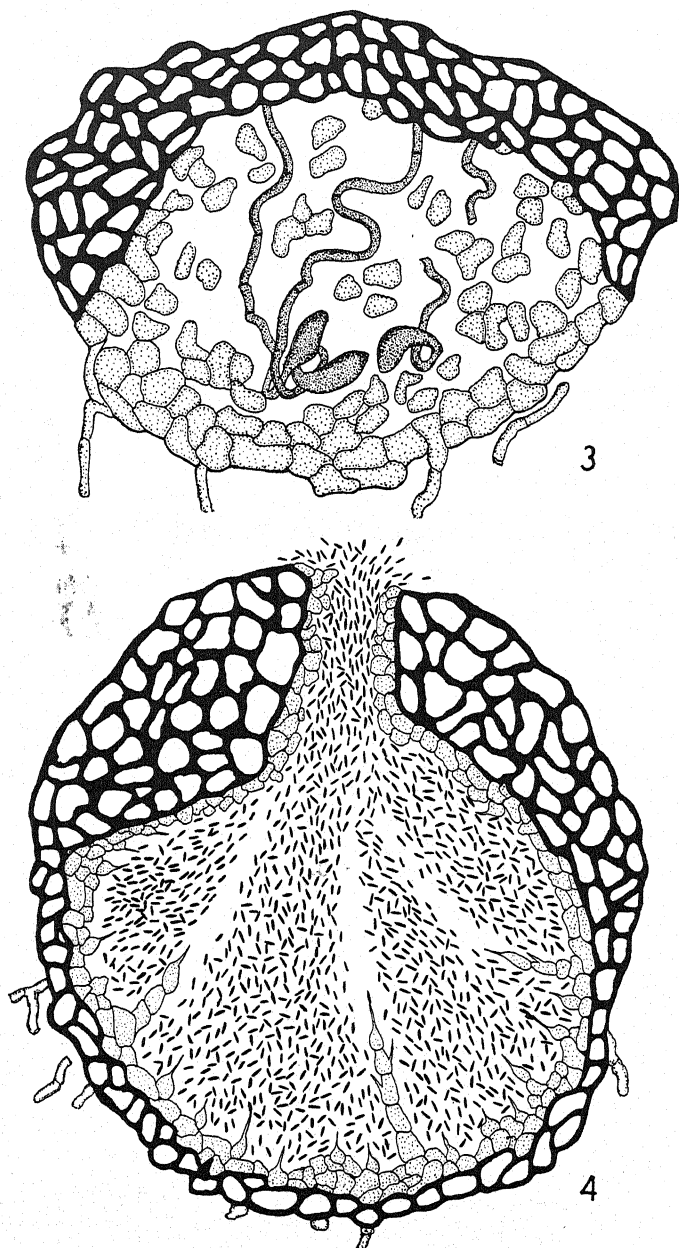


FIG. 3. Young perithecial stroma bearing three coiled carpogonia; 4, mature spermogonium of *M. fraxinicola*.

whether all except one disintegrate. Furthermore it is not known whether the spermatia function to fertilize the ascogonia before the development of ascogenous hypae and asci but, in all probability, such is the case.

In early spring the perithecial locules are filled with cells with dense protoplasmic content (FIG. 10) that appear to constitute the reserve food for the developing asci. Mature perithecia are spherical with a short ostiolar papilla, and vary in diameter from 75 to 100  $\mu$ . When perithecia are crushed in water on a microscopic slide a fascicle of asci is liberated. Mature asci measure  $40-50 \times 10-12 \mu$  and contain eight ascospores, usually biserially arranged (Fig. 8). The ascospores are hyaline, 1-septate, the basal cell being the smaller, and they measure  $8-10 \times 4-4.5 \mu$ .

*Life history.* An attempt was made to learn something of the life cycle of *M. fraxinicola* by use of cultures. Isolates from ascospores were secured by permitting them to be forcibly discharged onto inverted agar plates. Here they germinated readily (FIG. 12, 13) and small grayish-black to brownish-black colonies were developed. Tissue plantings from infected green leaves yielded similar colonies. Conidia were not produced in these cultures. All attempts to germinate spermatia failed.

Samples of decaying leaves that had remained out of doors continuously were examined at intervals from March 15 to July 1 to determine the duration of the period of ascospore discharge. Nearly all of the perithecia were empty by the latter date, and it may be concluded that *M. fraxinicola* is capable of discharging its ascospores over an extended period. On expulsion the ascospores are probably carried to the foliage by currents of air, and infection follows. The mycelium remains intercellular (FIG. 14), develops slowly, and pathogenesis is first evident about mid-August when the spermogonial and carpogonial stromata rupture the epidermis of the lower leaf surface. A conidial stage has not been found although such a stage is known to be commonly associated with other species of *Mycosphaerella*.

*Taxonomic resume.* Since this study genetically connects, for the first time, the so-called *Phyllosticta viridis* with *Mycosphaerella fraxinicola* it is desirable to emend the mycological description of the organism as follows:

MYCOSPHAERELLA FRAXINICOLA (Schw.) House. Ann. Rep. N. Y. State Museum 73: 27. 1921.

*Sphaeria fraxinicola* Schw. Trans. Am. Phil. Soc. 4: 224, 1831, No. 1787.

*Sphaerella fraxinicola* (Schw.) Cooke, Jour. Bot. 21: 107. 1883.

*Phyllosticta viridis* Ellis & Kellerm. Jour. Myc. 5: 142. 1889.

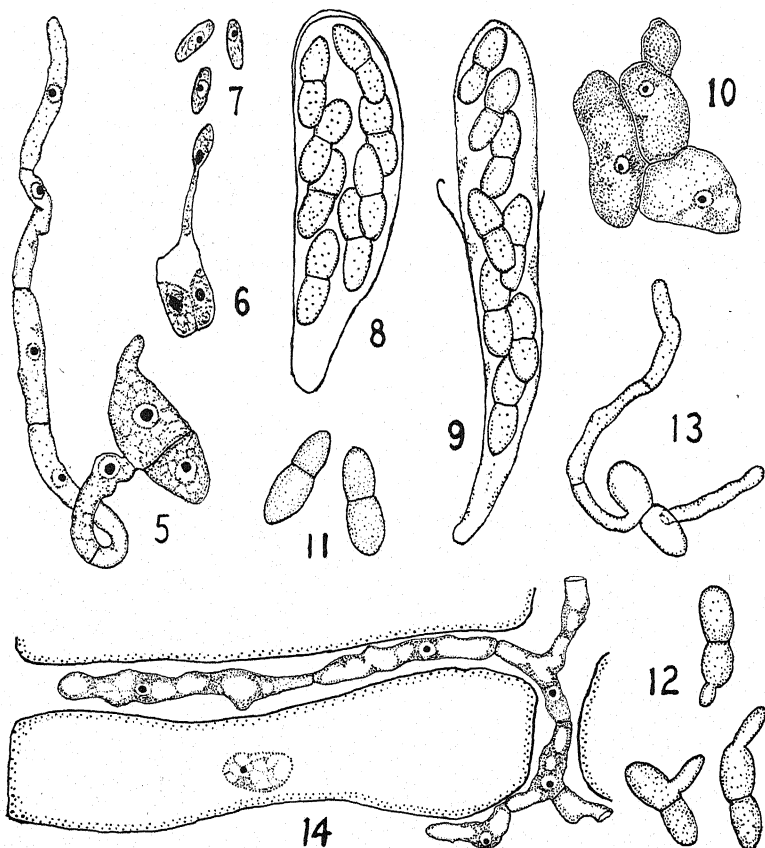


FIG. 5. A carpogonium with basal ascogonium and slender septate trichogyne; 6, spermatium mother cell, with sterigma like process on which a spermatium is being formed; 7, spermatia; 8, mature ascus of *M. fraxinicola* as seen when perithecia are macerated; 9, elongated ascus ready for discharge of ascospores; 10, uninucleate cells, densely filled with protoplasm, from the interior of a carpogonial stroma; 11, ascospores of *M. fraxinicola*; 12, 13, germinating ascospores; 14, palisade parenchyma cells and intercellular mycelium of *M. fraxinicola*.

Peritheciis hypophyllis, subinnatis, nigris, sparsis vel tantum conjunctis maculam atram efficientibus, minorem maculis quasi confluentibus inter se, sphaericis,  $70-100\ \mu$ ; ascis clavatis, abbreviatis, aparaphysatis, octosporis,  $40-50 \times 10-12\ \mu$ ; sporidiis biseriatis interdum inordinatis, subellipticis, uni-septatis, loculo inferiore teniore, hyalinis,  $8-10 \times 4-4.5\ \mu$ .

Hab. in pagina aversa foliorum Fraxini spp., frequens.

Status spermogonicus: Statum spermogonicum *Phyllosticta viridis* sistit. Maculis magnis, subindefinitis, margine subpallidioribus,  $0.5-1.5\ \text{cm. lat.}$ ; spermogoniis in stromatibus efformatis, suberumpentibus, punctiformibus, nigris,  $65-80\ \mu$  diam.; spermatiis intus loculo spermogonico oriundis, copiosis, bacilliiformibus, hyalinis,  $2-3 \times 1\ \mu$ .

Hab. in foliis vivis vel in laesionibus emortuis. Fraxini spp., in aestivo atque autumno.

For the convenience of mycologists, specimens have been deposited in the Farlow Herbarium, Harvard University, and in the herbarium of Mycology and Disease Survey, U. S. Department of Agriculture.

#### SUMMARY

The foliage of several species of *Fraxinus* may be affected by a fungus commonly identified as *Phyllosticta viridis* Ellis & Kellerm. This organism is widely distributed within the United States in the area east of the Rocky Mountains.

In late summer lesions form on the leaves and severe defoliation may follow. The presence of black stromata, protruding from the lower leaf surface, aids in diagnosis. The stromata at this stage have been found to contain both spermogonial and carpogonial locules, and the spermogonial stage is identical with *Phyllosticta viridis*. The carpogonial locules, each with one or more carpogonia, become transformed, by early spring, into mature perithecia. The perithecial stage has been identified as *Mycosphaerella fraxinicola* (Schw.) House.

The period of ascospore discharge extends into early summer. Infection is first apparent by the presence of stromata. The evidence in hand indicates that *M. fraxinicola* does not develop a conidial stage.

## EXPLANATION OF FIGURES

FIG. 1, Ash leaflets affected with the so-called *Phyllosticta* leaf spot; the outer ones, viewed from the lower surface, the middle one from above. Note the widely distributed black stromata on the two outer leaflets; 2, Perithecial stage of *Mycosphaerella fraxinicola* on ash leaflets; 3, Young perithecial stroma bearing three coiled carpogonia; 4, Mature spermogonium of *M. fraxinicola*; 5, A carpogonium with basal ascogonium and slender septate trichogyne; 6, Spermatium mother cell, with sterigma like process on which a spermatium is being formed; 7, Spermatia; 8, Mature ascus of *M. fraxinicola* as seen when perithecia are macerated; 9, Elongated ascus ready for discharge of ascospores; 10, Uninucleate cells, densely filled with protoplasm, from the interior of a carpogonial stroma; 11, Ascospores of *M. fraxinicola*; 12, 13, Germinating ascospores; 14, Palisade parenchyma cells and intercellular mycelium of *M. fraxinicola*.

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## STUDIES IN THE GENUS MYCENA. V<sup>1</sup>

ALEXANDER H. SMITH

(WITH 4 FIGURES)

During the season of 1937, with the aid of a grant from the Horace H. Rackham School of Graduate Studies of the University of Michigan, the writer was enabled to continue his investigations of the *Mycena* flora of the west coast. The locations selected for study were Blue River, Ore. on the western slope of the Cascade Mountains just below McKenzie Pass, and Crescent City, Calif., a small town on the coast a short distance south of the Oregon line. From the middle of October until the first of November, the *Mycena* flora on the moss and needle carpets under the various species of conifers which inhabit the western slope of the Cascades was the most luxuriant I have yet encountered anywhere. *Mycena tenax* Smith occurred everywhere in patches of hundreds of individuals, and *Mycena quinaultensis* Smith was more abundant than I have ever seen it before. *Mycena flavoalba* (Fries) Quél., a species I had not encountered previously, was very abundant under Douglas fir at elevations of between two thousand five hundred and three thousand five hundred feet. *Mycena rosella* (Fries) Quél. and *Mycena strobilinoidea* Peck, covered the needle carpet under pine. In addition to many of the known species, an exceptionally large number of species previously undescribed were also collected. Some of these were relatively rare and some were as abundant as *Mycena rosella* or *Mycena tenax*. The most interesting feature of the agaric flora at Blue River was the large proportion of species of *Mycena*. They made up about sixty per cent of the agaric flora. At Crescent City the ratio was closer to that usually found (five to twenty per cent). Here again, however, many very unusual species were found in greater abundance than those usually considered common. *Mycena haematopoda* (Fries) Quél. and *Mycena occidentalis* Murr., for instance, were rare.

<sup>1</sup> Papers from the Herbarium of the University of Michigan.



In this paper twelve species of *Mycena* are described as new. Ten of these were collected along the west coast, two being abundant in 1935 and rare in 1937. The remaining two are from eastern United States. One of these was obtained while the writer was engaged in a survey of the fungous flora of Oakland County, Mich., in cooperation with the Cranbrook Institute of Science, Bloomfield Hills, Mich. The other was collected in Michigan and New York during the season of 1934.

The collection numbers and photographs are the writer's. All color names are taken from *Color Standards and Color Nomenclature*, R. Ridgway, Washington, D. C., 1912. The collections are deposited in the Herbarium of the University of Michigan.

***Mycena corticalis* sp. nov.** (FIG. 1, B).—Pileus 6–12 (155) mm. latus, cylindricus vel convexus, demum late convexus, griseus, glabrus; cheilocystidia 20–25  $\times$  6–8  $\mu$ , clavata, echinulata; sporae 9–11  $\times$  7–9  $\mu$ .—Specimen typicum in Herb. Univ. of Mich. conservatum: Legit prope Blue River, Ore., Oct. 22, 1937, A. H. Smith No. 8046.

Pileus 6–12 (15) mm. broad, cylindric, conic or convex, remaining unexpanded, the disc often becoming slightly flattened, margin appressed against the stipe when young, glabrous, hygrophanous, when moist pale watery-gray on the disc, the margin whitish, translucent-striate, fading to cinereous and becoming sulcate; flesh thin, fragile, grayish, odor and taste mild; lamellae broad, arcuate or with a distinct decurrent tooth, rather distant, whitish to pale-gray; stipe 1–2.5 cm. long, 1 mm. thick more or less, equal, curved, tough and cartilaginous; glabrous, moist, concolorous with the pileus above or paler, faintly strigose where inserted on the bark; pileus trama with a very thin adnate pellicle, below it a region of inflated cells, the remainder of loosely arranged hyphae with very large cells; pleurocystidia not present; cheilocystidia imbedded and very inconspicuous, 20–25  $\times$  6–8  $\mu$ , with short contorted projections scattered over the apex; basidia four-spored; spores 9–11  $\times$  7–9  $\mu$ , broadly ovoid and pointed at one end, hyaline to pale bluish in iodine; gill trama wine red in iodine.

Scattered on cedar bark, Blue River, Ore., Oct. 22, 1937, No. 8046-type, Oct. 24, No. 8159; Kerby, Ore., No. 20, 1937, No. 8918. It has been found only on cedar logs and trees which lacked a covering of bryophytes. It is often found in company with *Mycena brevipes* Murr. and resembles that species in color and stature, but differs in its broad gills, wider spores and small imbedded

roughened cheilocystidia. *Mycena corticola* has globose spores (FIG. 1, C) and is a much smaller agaric.

***Mycena fragillima*** sp. nov. (FIG. 1, G; 2, B-C).—Pileus fragillimus, griseus, hydrophanus, demum cinereus; lamellae confertae vel subdistantes, adnatae, cinereae; stipes (3-7) 9-15 cm. longus, (1) 1.5-3 mm. crassus, fragillimus, pubescens; pleurocystidia et cheilocystidia  $34-48 \times 10-20 \mu$ , late fusoides, levia; sporae 7-9 (10)  $\times$  4-5 (5.5)  $\mu$ .—Specimen typicum in Herb. Univ. of Mich. conservatum: Legit Orick, Calif., Dec. 3, 1935, A. H. Smith No. 3744.

Pileus (5) 15-35 mm. broad, obtusely conic, becoming broadly campanulate to nearly plane in age, at first with a faint bloom, soon moist and watery, dark watery-gray and translucent-striate to the disc, becoming pale watery-gray or "hair brown" while still moist, hygrophanous and fading to very pale cinereous; flesh very thin, watery and fragile, grayish to pallid, odor and taste none; lamellae close in large caps, subdistant to distant in small individuals, adnate, pallid grayish with whitish even edges; stipe variable but long and slender (3-7) 9-15 cm. long, (1) 1.5-2 (3) mm. thick, usually decumbent, fragile, very pale watery-gray and minutely pubescent over all at first, soon polished and translucent, base white-strigose and sometimes slightly bulbous; pileus trama entirely of enlarged cells but with a thin adnate pellicle over the surface; pleurocystidia rare to absent, similar to cheilocystidia; cheilocystidia  $34-48 \times 10-20 \mu$ , hyaline, smooth, broadly fusoid with an acute apex which becomes drawn out into a long narrow neck (15-25  $\mu$  long) in age, forming a broad sterile band along the gill-edge; basidia four-spored; spores 7-9 (10)  $\times$  4-5 (5.5)  $\mu$ , pointed at one end, smooth, hyaline, bluish in iodine.

Gregarious on and around clumps of ferns, Booth, Ore., Nov. 24, 1935, No. 3620, and Orick, Calif., Dec. 3, No. 3744-type and Dec. 5, 1935, No. 3802. Judging from descriptions, the cystidia and spores separate this species from *Mycena vitrea* (Fries) Quél. and also from *Mycena vitreata* Britz. The fine pubescent covering of the stipe may also be a significant character, although it is one which might readily disappear if the specimens developed in an exposed area. The extremely delicate texture of both large and small fruiting bodies is the outstanding macroscopic character.

***Mycena madroñicola*** sp. nov. (FIG. 1, A).—Pileus 5-12 mm. latus, convexus vel subdepressus, brunneus demum avellaneus; lamellae distantes vel subdistantes, angustae vel latae, adnatae vel subdecurrentes; stipes 1-2 (3.5) cm. longus, 1 mm. crassus, pruinosis; cheilocystidia clavata, echinulata;

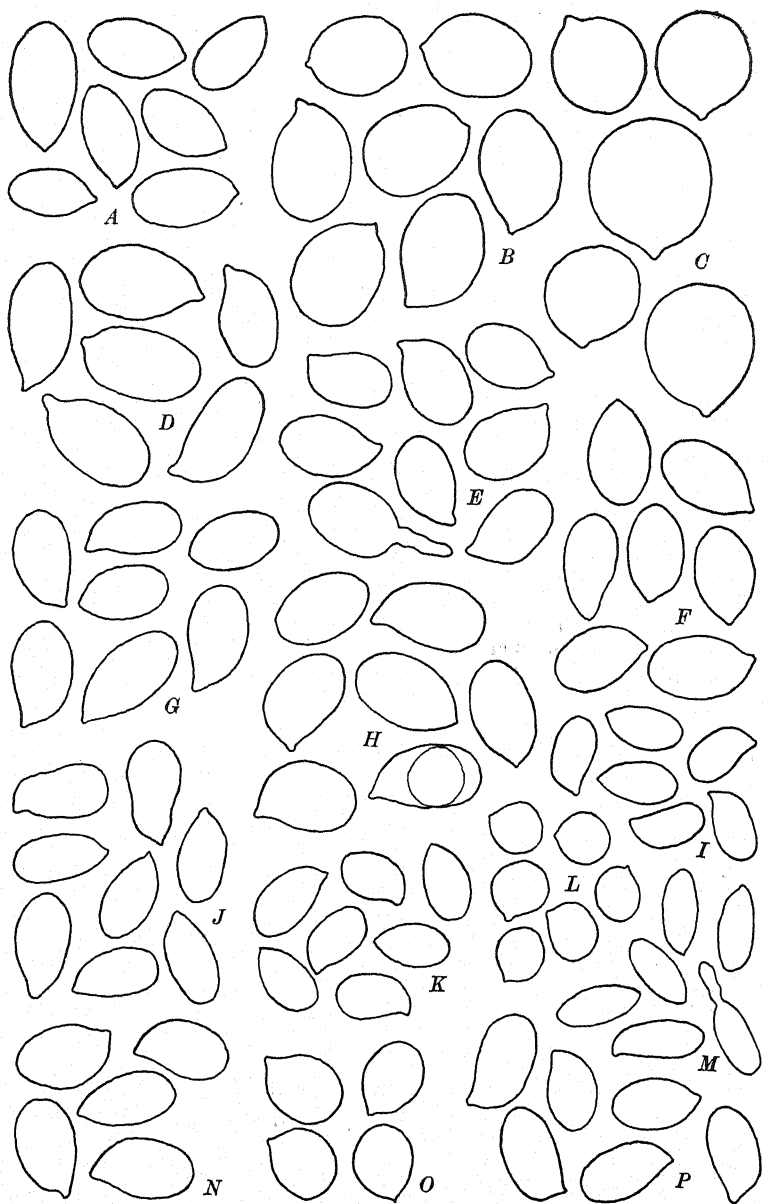


FIG. 1. A, seven spores of *Mycena madronicola*; B, seven spores of *Mycena corticola*; C, five spores of *Mycena sanguinolenta*; D, six spores of *Mycena sanguinolenta*; E, eight spores of *Mycena sanguinolenta*; F, five spores of *Mycena monticola*; G, seven spores of *Mycena fragillima*; H, seven spores of *Mycena subvitrea*; I, six spores of *Mycena pseudotenax*; J, eight spores of *Mycena pusilla*; K, seven spores of *Mycena piceicola*; L, six spores of *Mycena ulmicola*; M, six spores of *Mycena pelianthina*; N, five spores of *Mycena subplicosa*; O, four spores of *Mycena subcucullata*; P, six spores of *Mycena rutilantiformis*.

spores  $9-11 \times 5-6 \mu$  vel  $7.5-9.5 \times 4-5 \mu$ .—Specimen typicum in Herb. Univ. Mich. conservatum: Legit Kerby, Ore., Nov. 26, 1937, A. H. Smith, No. 9093.

Pileus 5–12 mm. broad, convex or with a somewhat flattened to subdepressed disc, not expanding, hoary when young, soon naked and in age more or less polished, moist, color “hair brown” to “cinnamon-brown” at first, fading to “avellaneous” or paler and with a whitish margin, at times “vinaceous-buff” or more grayish in age, when moist translucent-striate to the disc, becoming sulcate in age, margin at first appressed against the stipe; flesh concolorous, thin and pliant, odor when specimens were collected farinaceous but soon vanishing, no odor detected when specimens were unwrapped in the laboratory, taste mild; lamellae subdistant to distant, 14–18 (20) reach the stipe, narrow to moderately broad, broadly adnate but becoming toothed or more or less decurrent in age, color “tilleul buff” to pallid at all stages, edges even; stipe short 1–2 (3.6) cm. long, 1 mm. more or less thick, equal, base at first with a suboval bulb, tubular, concolorous with the pileus or paler, delicately frosted over all at first, base pruinose and inserted on bark as in *M. corticola*, apex pallid; pileus trama of three regions, a thin surface pellicle, a region of enlarged cells beneath it, and the remainder of floccose filamentose tissue; basidia four-spored; spores  $9-11 \times 5-6 \mu$  (in deposits), in revived material usually measuring  $7.5-9.5 \times 4-5 \mu$ , narrowly ellipsoid and pointed at one end, hyaline, smooth, bluish in iodine; pleurocystidia none; cheilocystidia variable, forming a more or less conspicuous band or imbedded in the gill-edge and inconspicuous,  $20-36 \times 5-9 \mu$ , clavate to capitate with short rod-like projections over the apex or the apex prolonged into a much branched contorted neck, sometimes smooth except for the branched apical portion.

Densely gregarious by the hundreds on bark of madroña trees in open places, after prolonged wet weather, Kerby, Ore., Nov. 26, No. 9093-type, Cave junction, Ore., Nov. 29, No. 9224, and Dec. 1, 1937, No. 9286. Because of the large number of immature spores in mounts of revived material one is likely to conclude that the spores are smaller than they actually are, and for this reason measurements from both spore deposits and dried specimens are included. The species is closely related to *Mycena corticola*. The truly ellipsoid spores, however, form a specific distinction which would enable one to recognize it even if both were found growing together. Although weather conditions were favorable for the development of *M. corticola*, it was not encountered during the season of 1937.

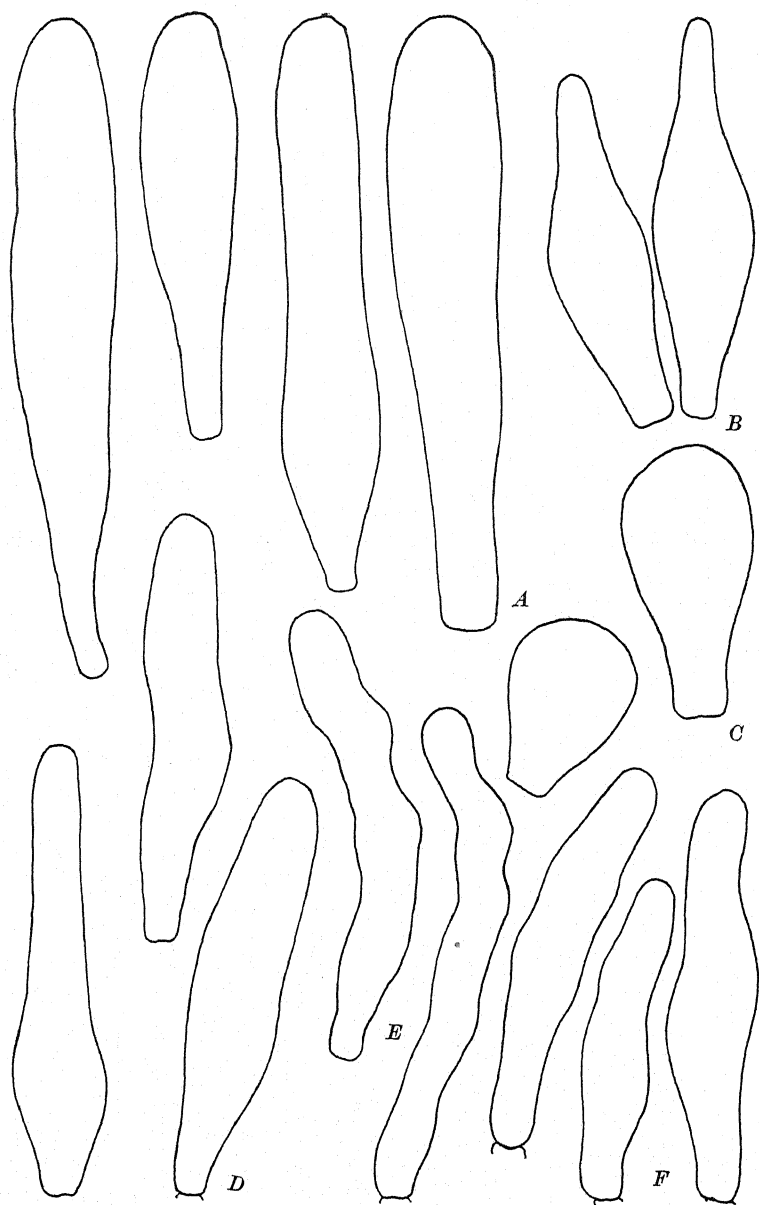


FIG. 2. A, four cystidia of *Mycena pseudotenax*; B, two mature cheilocystidia of *Mycena fragillima*; C, two immature cheilocystidia of *Mycena fragillima*; D, three cheilocystidia of *Mycena ulmicola*; E, two caulocystidia of *Mycena ulmicola*; F, three cheilocystidia of *Mycena subcucullata*.

***Mycena monticola*** sp. nov. (FIG. 1, *F*).—Pileus 1–3 cm. latus, conicus demum campanulatus, laete incarnatus; lamellae adnatae, confertae, latae, pallide incarnatae; stipes 4–7 cm. longus, 1–1.5 (2) mm. crassus, laete incarnatus; sporae  $7-10 \times 4-5 \mu$ ; cheilocystidia  $28-35 \times 9-12 \mu$ , echinulata.—Specimen typicum in Herb. Univ. Mich. conservatum: Legit prope McKenzie Pass, Ore., Oct. 18, 1937, A. H. Smith No. 7925.

Pileus 1–3 cm. broad, conic, obtusely campanulate becoming either plane or umbonate, the margin appressed against the stipe when very young or more often conivent to it, frequently with a wavy uplifted margin in age, glabrous, moist and hygrophanous, "pompeian red" on the disc and "light jasper red" to "coral pink" toward the margin, in some the disc is not darker, fading to "flesh color," when moist translucent-striate, the margin slightly sulcate when faded; flesh thin, incarnate, brittle, no odor or taste; lamellae ascending adnate, close, 23–28 reach the stipe, moderately broad to broad, edges even and whitish or tinged "flesh pink" to "coral pink" when the faces are similarly tinted; stipe 4–7 cm. long, 1–1.5 (2) mm. thick, equal above a narrowed crooked base, hollow, juice watery and scanty, very sparsely fibrillose at the base, apex faintly frosted, soon naked and polished, "coral pink" over all when fresh, soon becoming sordid brown from the base upward and finally "blister" over the lower portion; pileus trama homogeneous beneath a somewhat differentiated adnate pellicle; pleurocystidia none; cheilocystidia  $28-35 \times 9-12 \mu$ , clavate, with short echinulations over the enlarged portion; basidia four-spored; spores  $7-10 \times 4-5 \mu$ , ellipsoid or pointed at one end, hyaline to pale-yellowish in iodine.

Gregarious under pine, McKenzie Pass, Ore., 3500 to 4500 ft. elevation, Oct. 18, No. 7925-type, Oct. 21, No. 8014 and Oct. 23, 1937, No. 8104. In its cystidia and color it resembles *Mycena rosella* somewhat, but differs from that species in its broader gills, lack of pleurocystidia, and lack of a colored gill-edge. The bright colors of *M. monticola* remind one of *M. clava* but the echinulate cheilocystidia separate it at once. *M. monticola* was found growing abundantly under yellow pine on the eastern slope of the Cascade Mts. and also on the western slope under pine. In both habitats it was second only to *M. rosella* in abundance.

***Mycena piceicola*** sp. nov. (FIGS. 1, *K*; 3).—Pileus 2–3.5 cm. latus, obtusus demum late campanulatus, fuscus demum griseus; lamellae angustae, confertae vel subdistantes, adnatae, pallidae; stipes (2) 4–6 (8) cm. longus, 1.5–2 mm. crassus, strictus, griseus; cheilocystidia  $25-34 \times 6-10 \mu$ , echinulata; sporae  $6-8$  (9)  $\times$   $3.5-4$  (5)  $\mu$ .—Specimen typicum in Herb. Univ.

Mich. conservatum: Legit prope Siltcoos Lake, Ore., Nov. 13, 1935, A. H. Smith No. 3449.

Pileus 2–3.5 cm. broad, ovoid to obtusely conic at first, becoming broadly convex or broadly ovoid in age with or without a wavy margin, pruinose when young, soon naked, surface even and lubricous when moist, color dark livid-gray to “fuscous” or “hair brown,” the margin usually paler, fading to “drab” on the disc or sordid ashy-gray with a pallid margin, subhygrophanous and fading slowly, translucent-striate when moist; flesh watery-gray, thin, fragile, taste mild, odor subfarinaceous but faint and hardly distinctive; lamellae narrow, close to subdistant, adnate, whitish, then

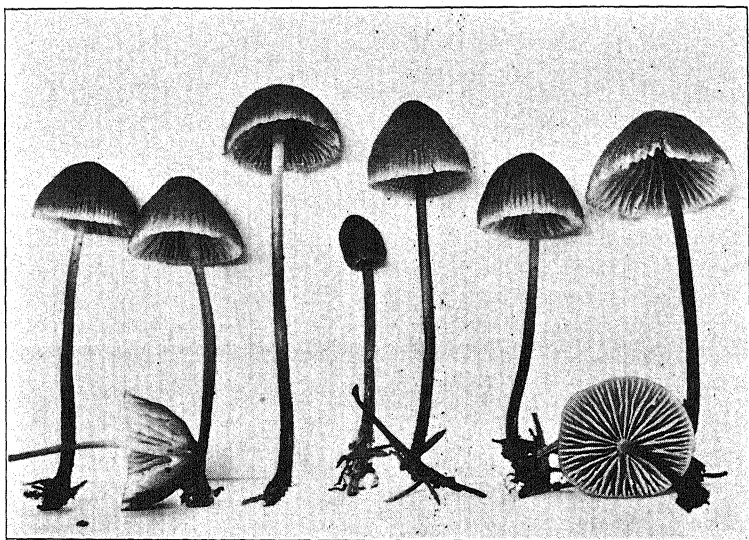


FIG. 3. *Mycena picicola*  $\times 1$ .

pallid or grayish with pallid edges, intervenose; stipe (2) 4–6 (8) cm. long, 1.5–2 mm. thick, equal, strict, fragile, tubular, dark bluish-gray at very first and soon fading to “drab” or sordid below, with a pallid apex, covered with a hoary bloom but soon naked and polished and more or less translucent, the base white strigose and somewhat inflated; pileus trama with a thin surface pellicle, a region of enlarged cells beneath it appearing pseudo-parenchymatous in tangential section, the remainder of loosely interwoven hyphae; pleurocystidia not differentiated; cheilocystidia 25–30  $\times$  7–11  $\mu$ , cylindric to clavate with obtuse short projections over the apices; basidia four-spored; spores 6–8  $\times$  3.5–4

or  $7-9 \times 4-5 \mu$ , smooth, hyaline, ellipsoid, hyaline to bluish-gray in iodine.

Gregarious or in troops of hundreds of individuals under spruce, Siltcoos Lake, Ore., Nov. 13, 1935, No. 3449-type; scattered under spruce, La Push, Wash., Oct. 25, No. 3324, and at Lake Tahkenitch, Ore., Nov. 19, 1935, No. 3548. Although fragile, the stipe does not split as in *M. dissiliens*. In many respects *M. piceicola* resembles *M. leptcephala* but the cystidia easily separate the two. It may perhaps be confused with large specimens of *M. plicosa*, but the lack of reddish-brown stains, narrower gills and thinner polished smooth stipe which does not break readily when one pulls the fruiting body from its attachment, all serve to distinguish it. There are differences in color also. I have never seen *M. piceicola* with a scalloped, crenate or sulcate-plicate margin of the cap although abundant fresh material of both has been seen. For further comments see *M. pusilla*.

***Mycena pseudotenax*** sp. nov. (FIGS. 1, I; 2, A; 4).—Tenax: pileus 1-3 cm. latus conicus demum plano-umbonatus, lubricus, fuscus vel griseus; lamellae confertae, angustae, subsinuatae, cinereae; stipes 3-5 (6) cm. longus, 1.5-2 (3) mm. crassus, strictus, glabrus, lubricus, griseus, luteo-strigosus; plerucystidia et cheilocystidia  $50-60$  ( $90$ )  $\times$   $10-12$  ( $15$ )  $\mu$ , subcylindrica; sporae  $5.5-7$  ( $8$ )  $\times$   $3.5-4 \mu$ .—Specimen typicum in Herb. Univ. Mich. conservatum: Legit prope Belknap Springs, Ore., Oct. 23, 1937, A. H. Smith No. 8134.

Pileus 1-3 cm. broad, obtusely conic or with a rounded apex when young, becoming expanded umbonate to nearly plane, the umbo usually broad and somewhat flattened, the margin often flaring in unexpanded individuals, glabrous, surface lubricous when wet, translucent striate to disc and the margin often creased or crenate in age, "fuscous" to pale watery-gray in young stages, at maturity pale watery gray over all or the margin whitish, fading to ashy-gray and appearing as if pruinose; flesh gray, thin but distinctly cartilaginous and thus causing the pileus to be very rigid, odor and taste mild; lamellae moderately close, 18-23 reach the stipe, adnate, becoming slightly sinuate, narrow to moderately broad and slightly ventricose at times, white becoming grayish in age, not becoming spotted, edges even and concolorous with the faces; stipe 3-5 (6) cm. long, 1.5-2 (3) mm. thick, equal, strict, cartilaginous-tough, glabrous, apex frosted from projecting cystidia, concolorous with pileus or paler, apex often whitish, base of stipe and surrounding fibrils whitish but soon becoming sordid



yellow; pileus trama with a very thin non gelatinous pellicle over the surface, the region beneath of enlarged hyphae and quite compact, the remainder floccose-filamentose with narrower cells; pleurocystidia abundant,  $50-60$  ( $90$ )  $\times$   $10-12$  ( $15$ )  $\mu$ , subcylindric with more or less rounded apices, arising in the subhymenium; cheilocystidia similar; basidia four-spored; spores  $5.5-7$  ( $8$ )  $\times$   $3.5-4$   $\mu$ , subellipsoid, pointed at one end, hyaline, smooth, bluish in iodine.

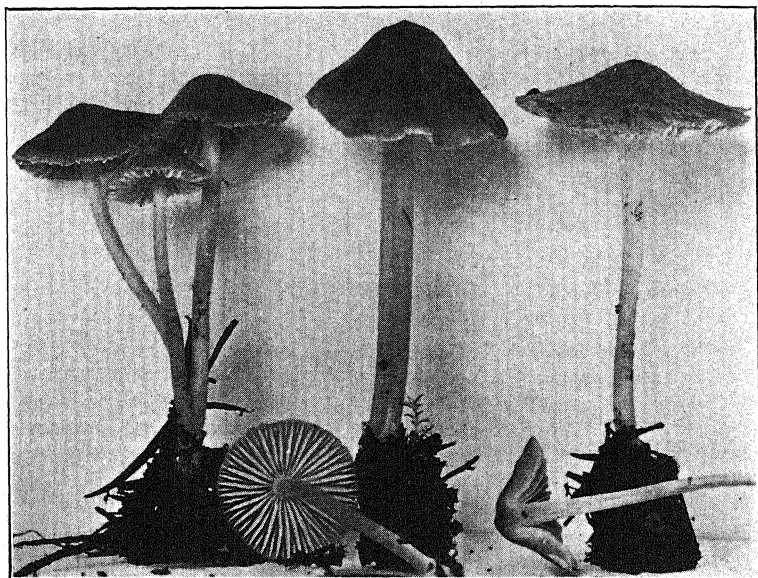


FIG. 4. *Mycena pseudotenax*  $\times 1$ .

Gregarious on needle beds under fir and cedar, Blue River, Ore., Oct. 16, No. 7835; South Fork of the McKenzie River, Oct. 20, No. 7967; McKenzie Pass, under pine, Oct. 21, No. 8025 and 8038; Blue River, under cedar and fir, Oct. 22, No. 8049; Deschutes National Forest, Ore., Oct. 23, No. 8105; Belknap Springs, Oct. 23, 1937, No. 8134-type. In California it was found under brush at the edge of a pasture, Smith River, Nov. 17, No. 8823, on Nov. 26 under fir near Patrick's Creek, No. 9071, and on Nov. 28, 1937, under redwood, Prairie Creek State Park, Orick, Calif., No. 9152. This was a common species at Blue River and easily recognized macroscopically by the cartilaginous-tough consistency, mild taste, yellow hairs at the base of the stipe and the slippery

feel. It might be mistaken for *M. tenax*, but the taste of the latter and its gelatinous stipe readily separate it without a microscopic examination. The yellow hairs at the base of the stipe at maturity, and the non-gelatinous stipe also separate it from *M. quiniaultensis*. *Mycena plumbeibrunnea* Murr. has smaller, acutely pointed cystidia on the sides and edges of the gills which measure  $35-54 \times 9-12 \mu$ . These are longer at times due to the proliferated apex. They are broadly fusoid when young in contrast to the cylindric rounded cystidia of *M. pseudotenax*. In addition, the spores of *M. plumbeibrunnea* measure  $8-10 \times 5-5.5 \mu$ . The latter should be carefully compared with *M. aetites* and *M. stannea* if fresh material can be found.

***Mycena pusilla*** sp. nov. (FIG. 1, J).—Pileus 5-10 mm. latus, convexus, demum subplanus, lubricus, cartilagineus, pallide griseus, striatus; lamellae confertae, latae, adnatae, albidae; stipes 2.5-4 cm. longus, 1 mm. crassus, lubricus, griseus; cheilocystidia  $26-30 \times 7-12 \mu$ , echinulata; sporae  $7-10 \times 5-6 \mu$ .—Specimen typicum in Herb. Univ. Mich. conservatum: Legit prope Crescent City, Calif., Nov. 11, 1937, A. H. Smith No. 8620.

Pileus 5-10 mm. broad, convex to obtuse or with a slightly flattened disc, in age more or less expanded plane or umbonate, disc pale watery-gray, the margin whitish, fading to pallid cinereous over all, surface hoary at first, glabrous and polished in age, lubricous when wet, striate to the disc when moist; flesh thin and membranous, grayish to pallid, odor and taste not distinctive; lamellae close, moderately broad, adnate, equal, white, edge even and concolorous; stipe 2.5-4 cm. long, 1 mm. thick, equal, tubular, whitish above, darker grayish-brown toward the base, with a bloom when real young, soon polished and lubricous but not viscid, tough; pileus trama with a thick subgelatinous pellicle, tissue beneath of somewhat enlarged cells; pleurocystidia not differentiated, cheilocystidia  $26-30 \times 7-12 \mu$ , clavate, hyaline, with short obtuse rod-like projections over the apex; basidia four-spored; spores  $7-10 \times 5-6 \mu$ , broadly ovoid, hyaline, smooth, bluish in iodine.

In troops of hundreds of individuals on moss, South Fork of the McKenzie River, Ore., Oct. 20, 1937, No. 9797, and under second growth fir, Siskiyou National Forest, Calif., Nov. 11, 1937, No. 8620-type; Crescent City, Calif., Nov. 17, 1937, No. 8834. This species puzzled me at first. It is most likely to be mistaken for the small form of *M. atroalboides*. When the two are compared, however, one becomes aware of certain differences, in fact,

the two impress one as being very different. *M. pusilla* is a lubricous tough little fungus whereas *M. atroalboides* is dry and fragile. When mounted in KOH the pellicle of the former gelatinizes appreciably and becomes 25–40  $\mu$  thick, that of the latter similarly treated measures 5–8  $\mu$ . *M. pusilla* resembles *M. constants* Peck in this character as well as in stature and color, but lacks a sharp odor. *Mycena subplicosa*, *M. piceicola* and *M. pusilla* can be distinguished from each other as follows: *M. subplicosa* has echinulate cystidia distributed over the faces of the gills as in *M. metata*. In the other two the cystidia are confined to the gill-edge. The pilei of *M. piceicola* measure 2–3.5 cm. and the whole plant is fragile. *M. pusilla* is smaller and very tough for a *Mycena*. The thick pellicle in KOH also distinguishes the latter from the former. *M. sepia* Lange may be the same as our short-stemmed form of *M. atroalboides*.

***Mycena subaquosa* sp. nov.**—Pileus 2–3.5 cm. latus, convexus, demum subplanus, glabrus, hygrophanus, aquosus, lacteus, demum subcandidus; caro albo, odore et sapore valde raphanoideo; lamellae confertae, latae, albidae; stipes 4–9 cm. longus, 2–3 mm. crassus, albidus, equalis, glabrus; pleurocystidia et cheilocystidia 40–60  $\times$  10–16  $\mu$ , fusoido-ventricosa; sporae 5–6.5 (7)  $\times$  2.5–3  $\mu$ .—Specimen typicum in Herb. Univ. Mich. conservatum: Legit prope Blue River, Ore., Oct. 15, 1937, A. H. Smith No. 7813.

Pileus 2–3.5 cm. broad, obtuse to convex, becoming broadly convex to nearly plane or the margin somewhat recurved in age, glabrous and moist, hygrophanous, watery and dull white except for the milky-white disc, at maturity the disc tinged with watery-gray, fading and becoming shining whitish, striate to disc when moist, margin appressed against the stipe at very first but soon conivent to it; flesh watery-white, very soft and fragile, odor and taste very pronounced, resembling that of radish or more pungent; lamellae close, 26–32 reach the stipe, in three to four tiers, broad and ventricose (3–4 mm.) adnexed, concolorous with the pileus, edges even and whitish; stipe 4–9 cm. long, 2–3 mm. thick, white and translucent, hollow, equal, very fragile, glabrous except for sparse white hairs at the base, apex naked or faintly frosted; pileus trama with a scarcely differentiated pellicle, below it a region of compact radially arranged hyphae, the remainder floccose-filamentose, pleurocystidia 40–60  $\times$  10–6  $\mu$ , fusoid-ventricose with rounded apices, hyaline; cheilocystidia usually shorter, 30–45  $\times$  9–18  $\mu$ , broadly fusoid, with or without an elongated neck, smooth; basidia four-spored; spores 5–6.5 (7)  $\times$  2.5–3  $\mu$ , narrowly ellipsoid, bluish in iodine, smooth.

Gregarious under cedar on moss, Blue River, Ore., Oct. 15, 1937, No. 7813-type. This species is similar to *Mycena pura* in its spores, cystidia and radish-like odor. Although *M. pura* was found everywhere in the conifer forests around McKenzie Pass during the 1937 season, it was consistently different from the specimens described above. In the whitish form of *M. pura*, according to my experience, the odor is not exceptionally strong, the colors are usually faintly pinkish or lilac on the disc and apex of the stipe, and the stature and consistency are the same as for the other forms of the species. In *Mycena subaquosa* the stature is more like that of *M. polygramma* than *M. pura*. This difference can not be considered a variation due to habitat because typical specimens of *M. pura* were collected in the same moss beds. The glabrous translucent stipe of *M. subaquosa* is quite different from the stipe of *M. pura*.

***Mycena subcucullata*** sp. nov. (FIG. 1, O).—Pileus 1–6 mm. latus, conicus demum subcampanulatus, fuscus demum pallide griseus vel sordide ochraceus; lamellae subdistantes, latae, albae; stipes 10–20 mm. longus, 0.5 mm. crassus, albidus vel griseus; pleurocystidia et cheilocystidia  $26-34 \times 8-12 \mu$ ; sporae 6–7 (8)  $\times 5-6 \mu$ ; basidia bispora.—Specimen typicum in Herb. Univ. Mich. conservatum: Legit prope Warrensburg, N. Y., Sept. 12, 1934, A. H. Smith No. 779.

Pileus 1–6 mm. broad, conic, campanulate or expanded plane with a conic umbo, umbo lacking in some, often more or less cucullate, colors fuscous on the disc or dark-gray, margin paler and finally whitish, disc also fading and often sordid ochraceous in age, sometimes white except for a sordid yellowish umbo, prominently striate when moist, often splitting readily in age; flesh thin, grayish, becoming white, rather cartilaginous, odor and taste not distinctive; lamellae subdistant to distant, broad, adnexed, white, thickish, edge even and concolorous; stipe 10–20 mm. long, 0.5 mm. thick, filiform but rigid, white to pale-gray, sordid below, rooting in moss on the bark of logs; pileus trama homogeneous below a thin pellicle, or the cells under the pellicle slightly enlarged; pleurocystidia scattered to rare, smooth, hyaline, saccate when young, subcylindric in age,  $26-34 \times 8-12 \mu$ , cheilocystidia similar or more saccate,  $25-30 \times 9-14 \mu$ , smooth, hyaline; basidia two-spored; spores 6–7 (8)  $\times 5-6 \mu$ , hyaline, smooth, hyaline to pale-bluish in iodine.

Gregarious on mossy logs, Warrensburg, N. Y., Sept. 12, 1934, No. 779-type and No. 784, also Sept. 14, No. 913; Marquette,

Mich., Sept. 10, 1934, E. B. Mains, No. 34-150. This is a small gray *Mycena* related in some respects to *M. epiphloea* (Fries) Sacc. but readily distinguished by its small spores and by the much smaller more saccate cystidia on the faces of the gills. It is almost identical in stature and appearance with gray forms of *M. mirata* Peck from which the cheilocystidia separate it at once.

***Mycena subsanguinolenta* sp. nov.** (FIG. 1, E).—Pileus 10-25 mm. latus, conicus, sordide rubrus, demum incarnato-flavidus; lamellae rubro-marginatae; pleurocystidia nulla; cheilocystidia  $28-35 \times 6-9 \mu$ ; sporae  $7-8.5 \times 3.5-4 \mu$ .—Specimen typicum in Herb. Univ. Mich. conservatum: Legit prope Blue River, Ore., Oct. 15, 1937, A. H. Smith No. 7809.

Pileus 10-25 mm. broad, conic, becoming obtusely conic-campulate, in age sometimes nearly plane but always with an abrupt obtuse umbo, hoary at first, soon glabrous and naked, moist, striate, in age sulcate to the disc, "burnt umber" near and on the disc, paler and near "vinaceous-buff" on the margin, in age a strong yellowish cast is evident throughout; flesh thin, yellowish or reddish under the disc, pliant, when cut exuding a watery orange-yellow latex, latex in the stipe blackish-red at first, later dull-orange, odor and taste mild; lamellae distant to subdistant, hooked, moderately broad, faces pale incarnate, edges dark reddish-brown; stipe 3-8 cm. long, 1-2 mm. thick, equal, fragile, hollow, base sparsely strigose with whitish hairs, apex hoary-pruinose, soon glabrous and naked, color pallid incarnate or concolorous with pileus margin, in age tinged yellowish; pileus trama with a thin surface pellicle, beneath it a region of more or less enlarged cells, the remainder floccose; pleurocystidia not differentiated; cheilocystidia numerous,  $28-33 \times 6-9 \mu$ , with a sordid reddish brown content, somewhat fusoid with subacute apices; basidia four spored; spores  $7-8.5 \times 3.5-4 \mu$ , smooth, hyaline, subovoid, bluish in iodine.

Densely gregarious under fir, Blue River, Ore., Oct. 14, No. 7775, Oct. 15, No. 7809-type; Lost Creek, Ore., Oct. 21, No. 8020; and Crescent City, Calif., Nov. 2, 1937, No. 8329. This species is separated from *M. sanguinolenta* by the smaller spores, lack of cystidia on the sides of the gills, and the more pronounced yellowish colors of the latex and also of both the pileus and stipe. Both species were observed in great abundance in California and were readily recognizable. Figure 1, D, illustrates the spores of *M. sanguinolenta*.

*Mycena subvitrea* sp. nov. (FIG. 1, H).—Pileus 1–3 cm. latus, conicus, glabrus, valde pellucido-striatus, atrofuscus vel cinereus; lamellae angustae, distantes, adnatae, cinerae, demum rufomaculatae; stipes 5–8 cm. longus, 1–2 (3) mm. crassus, pallidus, deorsum rufobrunneus; cheilocystidia 30–38  $\times$  9–12  $\mu$ , subventricosa; sporae 8–10 (11)  $\times$  (4) 5–6.5  $\mu$ .—Specimen typicum in Herb. Univ. Mich. conservatum: Legit prope Lost Creek, Ore., Oct. 21, 1937, A. H. Smith No. 8028.

Pileus 10–30 mm. broad, obtusely conic, remaining so or becoming campanulate, the disc becomes somewhat flattened at times, black to "fuscous" on the disc, watery-gray toward the margin, conspicuously translucent striate to the disc, fading to ashy or blackish-gray and sulcate, hygrophanous, glabrous, surface even and moist when fresh; flesh very thin and fragile, dark watery-gray, odor and taste not distinctive; lamellae rather distant, narrow, bluntly adnate, dark-gray and staining reddish-brown in age or where bruised, edge even, pallid; stipe 5–8 cm. long, 1–2 mm. thick, equal, very fragile and watery, hollow, pale grayish white, glabrous, apex frosted, readily staining reddish-brown when bruised or in age; pileus trama with a thin nongelatinous pellicle over a region of globular cells which have brownish contents, the tissue below this of filamentous hyaline hyphae; pleurocystidia not differentiated, cheilocystidia inconspicuous, subfusoid, smooth, hyaline, 30–38  $\times$  9–12  $\mu$ ; spores 8–10 (11)  $\times$  (4.5) 5–6.5  $\mu$ , ovoid, smooth, hyaline, bluish in iodine.

Gregarious under fir, Blue River, Ore., Oct. 15, No. 7811; Lost Creek, Ore., Oct. 21, No. 8020-type, Oct. 22, No. 8050; Belknap Springs, Oct. 24, 1937, No. 8160. The dark-gray, fragile, conspicuously striate pileus, pale fragile stipe, and tendency to stain reddish-brown when bruised or in age characterize it among the gray fragile *Mycenas*. It was found in company with *M. tenax* but was much less abundant. It is closest to *M. stannea* from which it is readily separated by the conspicuous broad blackish striations which extend to the disc, by the tendency of all parts to stain reddish brown, and by its more watery fragile consistency. It is also very close to *M. Murina* Murr. a species with pleurocystidia and one in which the lamellae and stipe do not change to reddish when bruised.

*Mycena ulmicola* sp. nov. (FIG. 1, L; 2, D, E).—Pileus 10–25 mm. latus, conicus demum umbonatus, fuscus, hygrophanus demum pallide cinereus, laceratus; lamellae confertae, angustae, candidae, adnatae vel adnato-decurrentes; stipes 2–3 cm. longus, 1.5–2 mm. crassus, equalis, valde pruinosis; cheilocystidia subcylindrica vel ventricosa, 40–50 (60)  $\times$  9–12  $\mu$ ; sporae

3.5-4  $\mu$ , globosae.—Specimen typicum in Herb. Univ. Mich. conservatum: Legit prope New Hudson, Mich., June 8, 1938, A. H. Smith No. 9537.

Pileus 10-25 mm. broad, obtusely conic, becoming umbonate with a flaring or recurved margin or sometimes nearly plane, with a narrow sterile margin which is curved in slightly at first but which soon becomes straight and more or less lacerated or split, "fuscous" on the disc at first and "buffy brown" toward the margin, becoming paler and often watery-gray before fading, hygrophaneous, fading to "olive buff" more or less or almost white, in age often splitting radially, surface even to slightly rugose, translucent, striatulate when moist; flesh thin, pliant, watery-gray, odor and taste mild; lamellae crowded, 18-25 reach the stipe, three to four tiers of shorter lamellae are present, narrow, white, adnate to subdecurrent at times, readily seceding, edges even, pallid and sometimes crisped or wavy; stipe 2-3 cm. long, 1-1.5 mm. thick, equal, solid, brittle and easily broken, white-strigose around the base, densely pruinose to subpubescent over all, whitish above, pallid to grayish or sordid yellowish near the base in age; pileus trama without a differentiated pellicle, the surface region composed of a compact mass of radially arranged hyphae which are one or two times the diameter of the hyphae making up the remainder of the tramal body, in tangential section the surface region appears cellular due to the cut hyphal ends; pleurocystidia present only near the gill-edge and similar to the cheilocystidia; cheilocystidia 40-50 (60)  $\times$  9-12  $\mu$ , hyaline, subcylindric to subventricose with obtuse apices; caulocystidia very numerous; 40-50  $\times$  8-10  $\mu$ , filamentous with obtuse apices, hyaline; basidia four-spored; spores 3.5-4  $\mu$ , globose to subglobose, smooth, hyaline, hyaline to faintly yellowish in iodine.

Gregarious on elm logs which have not lost their bark, usually on logs which are still quite sound, Pontiac, Mich., June 11, H. V. Smith (A. H. Smith, No. 6283); June 15, 1937, No. 6303, and near New Hudson, Mich., June 8, 1938, No. 9537-type. The compact surface layer of the pileus made up of radially arranged hyphae doubtless explains why the cap splits so readily and presents such a torn appearance in age. The species is close to *M. atribrunnea* Murr. but differs in habitat and in the lack of pleurocystidia. *M. Kauffmani* is readily distinguished by its pseudorhiza and colored gill-edges.

MYCENA RUTILANTIFORMIS Murrill (FIG. 1, P) (*Mycena denticulata* Peck, not *Mycena denticulata* Quél., 1888; *Mycena pseudo-*

*pelianthina* Lange, Mycologia 26: 9, 1934). Pileus (1.2) 2-7 cm. broad, convex, becoming broadly convex or in age at times with an elevated wavy margin, glabrous, moist to lubricous, hygrophanous, "natal brown" to "deep brownish drab" fading to near "avellaneous" or "vinaceous-buff," often paler and with a sordid yellowish cast, sordid purplish tints often persistent, margin striatulate when moist and frequently splitting in age; flesh moderately thick, yellowish to whitish, usually whitish in age, cuticle vinaceous in section, odor resembling that of radishes, taste similar or bitter and scarcely radish-like; lamellae close to subdistant, broad, adnate becoming sinuate or adnexed, seceding, intervenose, edges eroded to crenulate and sordid reddish-purple, faces "vinaceous fawn" or paler; stipe 3-8 cm. long, (3) 5-10 mm. thick, hollow, equal or base enlarged, somewhat longitudinally sulcate-striate, with scattered appressed purplish fibrils above, sometimes lacerate scaly from the broken cuticle, pallid grayish over all or the apex bright to sordid yellow beneath the purple fibrils, flesh grayish below, yellowish in the apex; pileus trama with a thin subgelatinous pellicle the cells of which may possess a reddish content, an indefinite region of enlarged cells beneath it, the remainder of floccose filamentous tissue (the pellicle may become washed or worn away in old pilei); pleurocystidia abundant,  $60-80 \times 9-15 \mu$ , smooth, with a reddish content; cheilocystidia similar or shorter; basidia four-spored; spores  $8-10 \times (3.5) 4-5 \mu$ , subovoid, smooth, hyaline, pale-bluish in iodine.

Gregarious on humus and debris under oak and hickory, Ann Arbor, Sept. 24, 1938, No. 11086. A form was collected near Joyce, Wash., in 1935, No. 2565, in which the characteristic odor and taste were lacking. Its spores measured  $7-9 \times 4-4.5 \mu$ . The spores of the type at the New York State Museum, Albany, N. Y., measure  $8-9 \times 4-4.5 \mu$ , and cystidia are abundant on the sides and edges of the gills. They measure  $48-60 \times 8-12 \mu$  and are filled with a dark brownish sap. In all of their macroscopic characters the type specimens are very similar to dried fruiting bodies of *M. pelianthina*. The specimens Kauffman (2) determined as *M. denticulata* Peck are more properly referred to *M. Kauffmanii* Smith. It is clear to me now, after observing *M. pelianthina* and *M. rutilantiformis* at various intervals over a ten year period that both are typically large fungi. Glatfelter's type collection happened to consist of exceptionally small individuals. Many of the specimens in my No. 11086 were well within the species as it was originally



described except that the pellicle was separable only in shreds. *M. rutilantiformis* differs from *M. pelianthina* in its broader spores, in the apex of the stipe which is usually yellowish at least within, and by the sulcate striations which are often present on the stipe. Lange gave a new name to the American species with yellow in the stipe and larger spores but otherwise like *M. pelianthina*, calling it *M. pseudopelianthina*. My studies indicate clearly that the latter name should be reduced to synonymy with *M. rutilantiformis*. Typical *M. pelianthina* also occurs in North America. During the past season it was collected in the same place on the same day—(No. 11087)—as *M. rutilantiformis*. Because it is one of the easiest Mycenas to recognize and since the literature is full of reliable descriptions, it does not seem necessary to redescribe it here.

*MYCENA SUBPLICOSA* Karsten.—Pileus 10–20 mm. broad, obtusely conic, becoming campanulate or expanded-umbonate, densely frosted-pruinose when young, the margin paler or whitish, fading to “hair brown” on the disc and finally dark sordid gray with a cinereous margin, or the margin becoming sordid ochraceous in age, striate to disc when moist, more or less sulcate when faded; flesh thin, scarcely fragile, grayish to pallid, odor and taste mild; lamellae narrow to moderately broad in age, adnate, close, whitish becoming gray, strongly intervenose, edges pallid; stipe 3–4 cm. long, 1.5 mm. thick, equal, tubular, rigid-cartilaginous but moderately fragile (not splitting as in *M. dissiliens*), base white strigose, concolorous with the pileus or paler, glabrous, apex frosted when young; pileus trama with a thin adnate pellicle over a region of inflated cells, the remainder filamentose; pleurocystidia and cheilocystidia similar,  $25\text{--}30 \times 8\text{--}15 \mu$ , saccate to pedicellate with a globose head, the upper portion covered with short rod-like projections, usually forming a broad sterile band on the gill-edge; basidia four-spored; spores  $6\text{--}8$  ( $9$ )  $\times 3.5\text{--}4 \mu$ , narrowly ellipsoid, hyaline, smooth, bluish in iodine.

Gregarious under spruce, La Push, Wash., Oct. 25, No. 3329; along the Quillayute River near Mora, Wash., Oct. 26, 1935, No. 3341; McKenzie Pass, Ore., Oct. 18, No. 7943; South Fork of the McKenzie River, Oct. 20, No. 7980, and at Blue River, Ore., Oct. 22, 1937, No. 8053. In California it was found under second growth spruce at Crescent City, Nov. 17, 1937, No. 8836 and No. 8833.

Karsten's species is here interpreted as having the same type of cystidia as *M. metata*. It differs from the latter in its dark colors and lack of an odor. The change to ochraceous which takes place in old caps is no way comparable to the brownish colors of the common form of *M. metata*.

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#### DESCRIPTION OF FIGURES

The drawings of the spores were made with the aid of a camera lucida and are magnified approximately 1500 times as reproduced. The drawings of cystidia are magnified approximately 900 times.

FIG. 1, A, seven spores of *Mycena madronicola*. B, seven spores of *Mycena corticalis*. C, five spores of *Mycena corticola*. D, six spores of *Mycena sanguinolenta*. E, eight spores of *Mycena subsanguinolenta*. F, five spores of *Mycena monticola*. G, seven spores of *Mycena fragillima*. H, seven spores of *Mycena subvitrea*. I, six spores of *Mycena pseudotenax*. J, eight spores of *Mycena pusilla*. K, seven spores of *Mycena piceicola*. L, six spores of *Mycena ulmicola*. M, six spores of *Mycena pelianthina*. N, five spores of *Mycena subplicosa*. O, four spores of *Mycena subcucullata*. P, six spores of *Mycena rutilantiformis*; 2, A, four cystidia of *Mycena pseudotenax*. B, two mature cheilocystidia of *Mycena fragillima*. C, two immature cheilocystidia of *Mycena fragillima*. D, three cheilocystidia of *Mycena ulmicola*. E, two caulocystidia of *Mycena ulmicola*. F, three cheilocystidia of *Mycena subcucullata*; 3, *Mycena piceicola*  $\times 1$ ; 4, *Mycena pseudotenax*  $\times 1$ .

## A NOTE ON PHLYCTIDIUM

J. S. KARLING

In a recent note (1937) I pointed out that the spelling of Gobi's (1879) algal genus *Asterocytis* differs slightly from de Wildeman's (1893) chytrid genus *Asterocystis* and that there were no orthographic grounds for substituting *Olpidiaster* for the latter, as Pascher (1917) had maintained. Shortly thereafter Arwidsson (1938), however, showed that Berkeley and Broome (1875) had used the name *Astrocystis* for a group of ascomycetes, and since *Asterocystis* is but an orthographic variation of the latter, Berkeley and Broome's genus has priority over de Wildeman's. Pascher's viewpoint has thus been confirmed, but from other evidence than that which he presented.

In a study of the early mycological literature I have found another case of priority among the chytrid genera. In 1855 Braun established *Phlyctidium* as a sub-genus of *Chytridium* to include non-operculate species whose intramatrical absorbing system consists of an unbranched peg, knob, or short filament. A few years later Rabenhorst (1868) raised it to generic rank, and since that time it has been recognized as such by most students of the chytrids. A survey of the literature, however, shows that Wallroth used this name for a group of ascomycetes as early as 1833, and since *Phlyctidium* was thus established subsequent to Fries (1821-1832) *Systema mycologicum*, it has status and validity under the present rules of nomenclature. Braun was apparently unaware of Wallroth's genus, for in none of his writings have I been able to find any reference to it. The thirteen ascomycetous species included by Wallroth in *Phlyctidium* have since been gradually transferred to other genera as far as I am aware, and the genus is no longer recognized among the ascomycetes except as a tautonymy.

As has been pointed out by numerous investigators, it is very doubtful whether the chytrids included at present in *Phlyctidium* are sufficiently different from those of *Rhizophidium* to justify a

separate generic group. Schröter (1889, 1897) and Fischer (1892) do not recognize *Phlyctidium*, but Serbinow (1907), Minden (1911–1915), and subsequent workers believe it merits distinction. As noted above, its species differ from those of the other genus by the presence of a single unbranched knob, peg, or filament instead of a branched rhizoidal system. Obviously this is not a very fundamental generic character and of sufficient significance for separating the genus from *Rhizophidium*. Nor is it very practicable. When species occur on algal cells filled with degenerating plastids, starch grains, etc., the absorbing system may be completely obscured, and in such cases it is almost impossible to determine the genus to which a species belongs.

In recent years, however, various types of sexuality have been reported by Scherffel (1925), Sparrow (1933), and Couch (1935) for *Rhizophidium*, but sexuality is still unknown in *Phlyctidium*. It is accordingly probable that when the two genera are better known a more fundamental basis for separating or merging them may be found. None the less, for the time being and in the event that more fundamental evidence is found for the justification of a distinct genus, I am proposing the name **Tylochytrium**<sup>1</sup> nom. nov. as a substitute for Braun's *Phlyctidium* with the object of emphasizing the unbranched knob, peg, or filament which projects into the host cell.

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## TWO SPECIES OF HYSTERIALES ON SMILAX

EDITH K. CASH

(WITH 2 FIGURES)

For many years confusion has existed regarding two species of the Hysteriales occurring on stems of *Smilax* in North America, so similar in macroscopic appearance, particularly in their early stages of development, that the distinction between them has not been clearly recognized. Both of these fungi have been referred to *Hysterium Smilacis* Schw. One is a species of *Gloniopsis*, called *Gloniopsis Smilacis* (Schw.) Underw. & Earle, or *Hysterographium Smilacis* (Schw.) Ellis & Ev.; the second a Hypodermataceous fungus generally known as *Hypoderma Smilacis* (Schw.) Rehm, although it would appear to belong more properly in the genus *Hypodermopsis*. In well developed material the *Gloniopsis* can be distinguished by its superficial fruiting bodies as contrasted with those of the *Hypodermopsis*, which remain beneath the epidermis even when mature. The most evident difference is in the character of the spores, which are hyaline and muriform in the former, brown and 3-septate in the latter.

The superficial resemblance of these two species and their growth on the same host has led to mixed collections, apothecia of both fungi being sometimes present on the same stem, only a few centimeters apart. It is apparent from the literature that the original Schweinitz specimen must have been such a mixed collection, and that some of the authors who examined his specimen found and described the one, some the other of the two species. An added source of confusion is the fact that some descriptions appear to combine characters of both fungi under a single name.

### HISTORY

The original description of *Hysterium Smilacis* Schw. (11, p. 23, 1822), based on a collection from Salem, North Carolina, is

applicable to either of the two fungi, except that the dimensions of the hysterothecia are rather more typical of the *Hypodermopsis*:

H. sparsum lineare longitudinaliter situm atrum, minutissime tuberculatum, labiis laevibus tenuibus.

Non rarum ad emortuos ramos Smilacis rotundifoliae.—Longitudo 3 linearum. Labia parum elevata non striata.

Through the kindness of Dr. Francis W. Pennell, the writer had the privilege of examining a specimen in the Schweinitz Herbarium, which is part of the original gathering of Schweinitz from Salem. The hysterothecia present in this specimen are apparently all those of the *Gloniopsis*; however, there can be no doubt that both species were originally present in the collection.

Fries (7, p. 586, 1823) copied Schweinitz' description, with the addition of a few lines giving his own observations. His note "v.s." indicates that he had a part of Schweinitz' original Salem collection.

Hoc, ut plurima innata, primo obtuto superficiale videtur, sed quoad nostra spec. potius innatum, gracile, 2-3 lin. longum, labiis laevibus subnitidis prominulis, disco in clauso lineari. Ad emortuos ramos Smilacis rotundifoliae. Carolinae. (v.s.)

The superficial fruiting-bodies in Fries' specimen are presumably those of the *Gloniopsis*, while those described as slender, innate, 2-3 lines long, are more likely to belong to the *Hypodermopsis*. However it is impossible to assign the description positively to either of the two species, in the absence of any really distinctive characters.

The first mention of spore character in *Hysterium Smilacis* is given by Duby (4, p. 32, *pl. 1, f. 14*, 1861), in describing and illustrating material sent from New England by Curtis, which, however, he noted as probably immature. Duby described "sporas ovatas hyalinas nucleis subglobosis tribus faetes 2-seriales." Immature, hyaline, biseriate spores containing three nuclei might belong to either of the two fungi. The term "ovate" is more characteristic of *Gloniopsis*, since immature spores of the *Hypodermopsis*, exclusive of the gelatinous envelope, are fusoid.

Among the collections studied by Billings in obtaining data for his synopsis of the genus *Hysterium* (1, p. 630, *pl. 11, f. j*, 1871), he cites "authentic specimens in the Schweinitz Herbarium," so

that there can be little doubt that his description of *Hysterium Smilacis* Schw. is based on type material. The spores are said to be "colourless, subpyriform, .001-.0013 inch long, with a gelatinous envelope when young." His description, and more particularly his figure, clearly indicate that he was dealing with the *Hypodermopsis*, although immature, since the spores are still hyaline, one-septate, and surrounded by a conspicuous gelatinous sheath. This is, therefore, the first description of *Hysterium Smilacis* with which collections can be identified with certainty.

Rehm's Ascomycetes no. 318<sup>1</sup> was issued as "*Hypoderma Smilacis* (Schweinitz sub *Hysterium*).". The combination is given in the same form in the published list of the exsiccati (9, p. 80, 1881), with a description of the asci and spores. The species is included in *Hypoderma* in spite of the fact that the spores are noted as four-celled. Examination of the specimen of Rehm's Ascomycetes No. 318 in the Mycological Collections of the Bureau of Plant Industry shows that the material contains both the *Gloniopsis* and the *Hypodermopsis*, but apparently Rehm found only the latter.

The first European record of *Hysterium Smilacis* is that made by Thümen (12, p. 24, 1881), who lists the fungus without description on *Smilax aspera* and *S. mauritanica* from Portugal. Oudemans (8, p. 1188-1189, 1919) and Saccardo (10, p. 789, 1883) record the same hosts. No European specimen has been examined by the writer, and no other reference has been found to collections from elsewhere than the United States.

Under the name of *Hypoderma Smilacis* (Schw.) Rehm, Saccardo (10, p. 789, 1883) copied Fries' description, with the addition of notes on the asci and spores, evidently translated from Rehm: "ascis clavatis, crasse tunicatis, ramuloso-paraphysatis,  $75 \times 18$ , octosporis; sporidiis elongato-fusoideis, obtusiusculis, 4-cellularibus, 2-4-nucleatis, medio subconstrictis,  $27 \times 8$ , hyalinis." There is no indication that Saccardo examined Schweinitz specimens.

The next record of an examination of Schweinitz' material of *Hysterium Smilacis* is that made by Ellis and Everhart (6, p. 709,

<sup>1</sup> Rehm: Ascomyceten 318, *Hypoderma Smilacis* (Schweinitz sub *Hysterium*). Ad smilaces varias emortuas, Newfield (New Jersey), N. Amerika, 12/ 1875, Ellis, 1876.



1892). Their description is a composite of characters of both fungi, partly copied from Schweinitz, partly based on Ellis' collections, but seems to apply in the main to the *Gloniopsis*. The spores are described as "biseriate or inordinate, clavate-oblong or clavate-fusoid, yellowish hyaline, 3-5-pseudoseptate, one or two of the inner cells divided by a longitudinal septum, 12-20 (mostly 15)  $\times$  4-5  $\mu$  or, including the gelatinous envelope, 7  $\mu$  wide." It is obvious from this description of the spores that Ellis found the *Gloniopsis* in the Schweinitz specimen. Since Ellis and Everhart considered *Gloniopsis* as a subgenus of *Hysterographium*, the species is listed in the North American Pyrenomycetes (6, p. 709) as *Hysterographium Smilacis* (Schw.) Ellis & Ev.

The combination *Gloniopsis Smilacis* was made by Underwood and Earle (13, p. 196, 1897), with the observation: "This is evidently a *Gloniopsis* and not a *Hypoderma*, where it is placed by Rehm and Saccardo."

Wilson and Seaver, Ascomycetes and Lower Fungi no. 5 was issued under the name *Gloniopsis Smilacis* (Schw.) and the combination published (14, p. 49, 1907) in the annotated list of the first fascicle of their exsiccati set. *Hysterium Smilacis* Schw., *Hypoderma Smilacis* (Schw.) Sacc. and *Hysterographium Smilacis* (Schw.) Ellis & Ev. are given as synonyms of the new combination, which is, however, antedated by the publication of the same name by Underwood and Earle in 1897. The specimen of Wilson and Seaver Ascom. and Lower Fungi 5 in the Mycological Collections is the *Gloniopsis*.

*Hysterium Smilacis* is not included among the species discussed by Bisby (2, 1932) in his studies of type specimens of certain Hysteriales.

To summarize, it may be seen from the above citations that Ellis, Underwood and Earle, Wilson and Seaver, and probably Duby, on the one hand, are dealing with the *Gloniopsis*, while Billings, Rehm, and Saccardo had under discussion the *Hypodermopsis*.

#### TAXONOMY

Since the descriptions of Schweinitz, Fries, and Duby fail to show to which of the two species present in the type collection they

refer, that of Billings (1, p. 630, *pl. 11, f. j*) in 1871 is the first recognizable account of the fungus. It may therefore be permissible to consider the fungus which he described as the type of *Hysterium Smilacis*. The genus *Hypoderma* in Darker's classification (3, p. 15, 1932) is applied to species having one-celled, hyaline spores. In the fungus under consideration, the spores are clearly two-celled in a very early stage, later becoming brown and eventually four-celled; it can not, therefore, be retained in the genus *Hypoderma*. The only genus in the Hypodermataceae described with dark, three-septate spores is *Hypodermopsis* Earle (5, p. 345, 1902), of which *H. Sequoiae* Earle is the type species. Part of the type collection of this species,<sup>2</sup> deposited in the Mycological Collections by the courtesy of Dr. David H. Linder, has been examined. While the spores are darker in color and the paraphyses are more distinct in *Hypodermopsis Sequoiae* than in the fungus on *Smilax*, the two species agree so closely in general structure that *Hysterium Smilacis* Schw. may be included in Earle's genus.

If the fungus described by Billings is to be considered as the type of *Hysterium Smilacis* Schw., it becomes necessary to rename the *Gloniopsis*, which is therefore given the specific name "*Ellisii*."

1. *Hypodermopsis Smilacis* (Schw.) comb. nov. (FIG. 1, A; 2, A).

Syn.: *Hysterium Smilacis* Schw. sec. Billings, Am. Nat. 5: 630, *pl. 11, f. j*. 1871 (= *Hysterium Smilacis* Schw. Syn. Fungorum Carol. Super. p. 23, 1822, p. p.).

*Hypoderma Smilacis* (Schw.) Rehm, Ber. Naturf. Ver. Augsburg 26: 80, 1881.

Hysterothecia subepidermal, 0.5–1 × 0.2–0.3 mm., occasionally confluent up to 2 mm. long, scattered or closely grouped, usually arranged lengthwise along the stems, straight or rarely slightly curved, obtuse, membranous, dull-black, smooth, opening by a slit, nearly closed even when mature, closely covered by the blackened epidermis and showing only a narrow portion along the slit; asci broad-clavate, obtuse at the apex, short-stipitate, 65–80 × 20–24  $\mu$ ;

<sup>2</sup> *Hypodermopsis Sequoiae* Earle, sp. nov., Pacific Slope Fungi no. 81, distributed by C. F. Baker.

spores long-fusoid, at first hyaline and two-celled, and surrounded by a conspicuous gelatinous sheath  $2.5\ \mu$  thick, becoming brown and finally 3-septate,  $20\text{--}27 \times 7\text{--}9\ \mu$ , constricted at the middle septum, the upper portion usually slightly broader than the lower; paraphyses hyaline, filiform, branched and interwoven, soon conglutinated into a dense yellowish epithecium; basal layer thin, hyaline; covering layer above and at sides black,  $10\text{--}15\ \mu$  thick, adnate to the epidermal cells,  $35\text{--}55\ \mu$  thick including the epidermis.

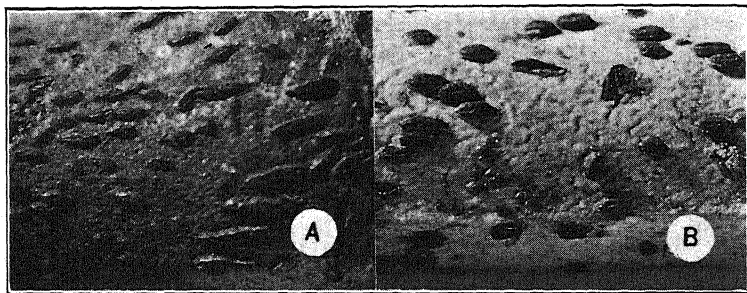


FIG. 1. A, hysterothecia of *Hypodermopsis Smilacis*,  $\times 5$ ; B, of *Gloniopsis Ellisii*,  $\times 4$ .

On dead or dying stems of *Smilax rotundifolia*, and *Smilax* sp., New York, Pennsylvania, New Jersey, Maryland, Virginia, North Carolina, and Louisiana.

Exsiccati: Thüm. Myc. Univ. 662; Rehm Ascomyceten 318, p. p.

2. *Gloniopsis Ellisii* nom. nov. (FIG. 1, B; 2, B).

Syn.: *Hysterium Smilacis* Schw. Syn. Fungorum Carol. Super. p. 23, 1822, p. p.; Duby, Mém. Hyst. p. 32, pl. 1, fig. 14, 1861 (?).

*Hysterographium (Gloniopsis) Smilacis* (Schw.) Ellis & Ev., N. Am. Pyren. p. 709, 1892.

*Gloniopsis Smilacis* (Schw.) Underw. & Earle, Ala. Agr. Exp. Sta. Bull. 80: 196. 1897.

*Gloniopsis Smilacis* (Schw.) Wilson & Seaver, Jour. Myc. 13: 49, 1907.

Hysterothecia at first subepidermal, then emerging and becoming superficial, elliptical to elongate,  $0.4\text{--}0.7 \times 0.3\text{--}0.5$  mm., irregularly scattered lengthwise or less often crosswise on the stems, black, smooth to slightly roughened, opening by a narrow slit, lips some-

times faintly striate, rather acute at the ends; asci cylindrical-clavate, often curved or irregularly constricted, obtuse with wall thickened at the apex, gradually narrowed toward the base,  $65-80 \times 15-18 \mu$ ; spores subpyriform to clavate, hyaline, muriform, slightly constricted near the center, the upper portion broader than the lower, 4-6-septate, with the center cells longitudinally divided, surrounded when young by a narrow, inconspicuous, hyaline, gelatinous envelope which soon disappears,  $15-22 \times 5-8 \mu$ ; paraphyses filiform, numerous, repeatedly branched, interwoven, forming a

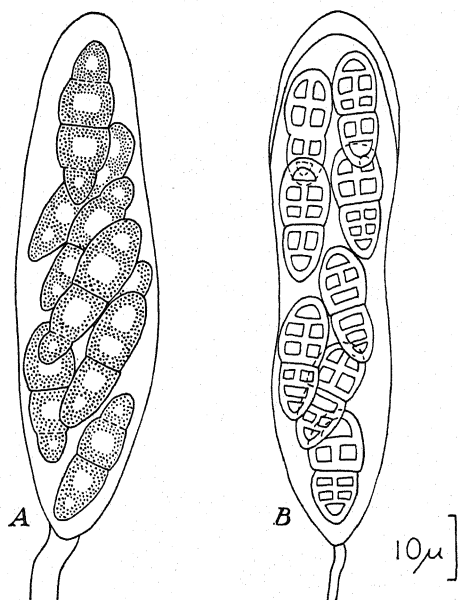


FIG. 2. A, ascus of *Hypodermopsis Smilacis*; B, of *Gloniopsis Ellisii*.

brownish epithecium; hypothecium thin, pale brownish, underlying and covering cortex black, carbonous,  $45-65 \mu$  thick below,  $60-75 \mu$  thick above.

On dead or dying stems of *Smilax* sp., Rhode Island, New York, New Jersey, Maryland, Virginia, Alabama, Florida, and Louisiana.

Exsiccati: Wilson & Seaver, Ascom. and Lower Fungi 5; Ellis & Ev. N. Am. F. 2375; Ellis F. Nova-Caesarenses 66; Rehm Ascomyceten 318, p. p.

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type specimens in the Philadelphia Academy of Sciences and the Farlow Cryptogamic Herbarium, Cambridge, Mass.

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## THE GENUS HYPOCHNUS AND FRIES'S OBSERVATIONES

DONALD P. ROGERS

(WITH 6 FIGURES)

Before any student of the fungi can safely shape into final form monographic work on *Corticium*, on *Peniophora*, on *Coniophora*, especially on *Tomentella*, or on any of a number of lesser genera related to these, there is a purely nomenclatorial question which must be given what will for him be its final answer: the question of the application of the Friesian generic name *Hypochnus*. Such a ghost cannot be laid by incantation, nor even by solemn pronouncement of its inconsequence; rare is the problem solved by the wisdom of the ostrich. Yet within the memory of persons now living one<sup>1</sup> who would wish to be accounted a man of science submitted to an American scientific society the thesis that its members might well "leave nomenclature to arm-chair botanists." It is conceivable that in an effete and inane scientific utopia where all substances could be treated in the universal abstraction of a single formula, all processes expressed in a single transcendent equation, and all organisms comprised in a single Platonic pattern there would no longer be a place for the particularizing now sometimes felicitously achieved in nomenclatorial niceties. But so long as the imperfection of the sciences compels their students to deal with lesser truths than the ultimate universal, looseness in scientific nomenclature will be the agent of obfuscation, and the signature of unscientific looseness of thought. For the achievement of nomenclatorial precision in one minute corner of mycology, and thus as an infinitesimal step towards the attainment of the utopia in which nomenclatorial laziness would be something less than the shirking of responsibility, there is here presented a study of this single generic name.

<sup>1</sup> "Viros, a quorum receptis opinionibus subinde abii, non ubique nominavi. Non enim animus erat contradicendi, sed rite exponendi naturam" (22).

That the name *Hypochnus* Fries has been applied, with full show of validity, to several quite diverse groups of fungi is largely attributable to the extraordinary ambiguity of Fries's own conception of his genus. In his first treatment, in his *Observationes* (8), *Hypochnus* includes (1) *H. sereus*, a species which according to the classification of the Thelephoraceae current in this country (6) must be placed in *Peniophora*; (2) a *Corticium*, *H. coeruleus*; (3) *H. fumosus*, a member of the homogeneous group of Thelephoraceae with minutely asperulate spores which, variously assigned to *Corticium* sect. *Humicola* Bourdot & Galzin and to *Hypochnus* sensu Burt, belong in neither, but in their own genus, *Cristella* Patouillard; (4) two members, including the type, *H. ferrugineus*, of the genus *Tomentella* Patouillard; (5) *H. isabellinus*, a member of the highly characteristic genus *Botryobasidium* Donk (20); (6) *H. olivaceus*, which Bourdot and Burt have agreed in declaring a cystidiate *Coniophora* (*Coniophorella*); and (7) two dubious species, *H. aureus* and *H. helvolus*, which may possibly have been imperfecti or lichens. *Hypochnus* of the *Systema*<sup>2</sup>—" *Hypochnus* Fr. Ehrenb." (10); that is, *Hypochnus* of Fries as emended by Ehrenberg—has only the name and the doubtful *H. aureus* in common with that first genus. Although in the *Epicrisis* (11), twenty years after the publication of the first *Hypochnus* (8), it was given as Fries's judgment that two of the three species included in the second (10) were "Genuini," according to his own final decision (12) they are not Thelephoraceae, but lichens. Further, it is recorded that Fries himself appreciated the confusion which involved his genus. In the thesis *Genera hymenomycetum* (16), whose authorship he subsequently acknowledged in the citation "Fr. Gen. Hymen." (11, p. 315 et passim), *Hypochnus* is described as "Genus varia ratione interpretatum et interpretandum"—at once a history and a promise of ambiguity.

<sup>2</sup> The circumscription of *Hypochnus* forever established, under the Rules, by incorporation in the *Systema mycologicum* actually was first published by Fries in the *Systema orbis vegetabilium* (9). There he wrote, evidently of the earlier *Hypochnus* of the *Observationes*, "Species nostrae plurimae excludendae." But because no species were described for *Hypochnus* in the *Systema orbis vegetabilium* it is not there, but in the *Systema mycologicum*, that one must look for the valid and definitive publication.

It is no wonder that from such beginnings later mycologists have worked out in various directions. "*Hypochnus* as given in Engler & Prantl's 'Die Natürlichen Pflanzenfamilien' [first edition and, more's the pity, second also] is the presentation of a purely academic scheme of Schroeter's as to how the lower Hymenomycetes ought to be classified to have a family Hypochnacei" (5). Schroeter's *Hypochnus* (21) is exactly such a mixture of forms as the genus of the Observationes: it includes species of *Corticium*, *Peniophora*, *Botryobasidium*, *Cristella*, *Aleurodiscus*, and *Hymenochaete*; the first species, *H. bisporus*, is a *Corticium*, according to present standards. Schroeter's genus and family are both characterized by cylindric basidia and loose texture—and by nothing else. Brefeld's incredible Tomentellei (2), which includes *Pachysterigma* (i.e., *Tulasnella*) and *Exobasidium* along with something called *Hypochnus*, arose as a result of his similarly attributing to looseness of basidial arrangement great importance as a principle of limitation, and to other microscopic characters, even less than Schroeter. Karsten defined "*Hypochnus* Fr." not as Fries had done, by the vague character of texture alone, but by "*Hymenium tomentosum*. *Sporae aculeatae*" (14). Since Karsten and the rest have treated this *Hypochnus* as an emended Friesian genus, its type must be chosen from among Fries's species; of these there is included in Karsten's *Hypochnus* but the one, *H. olivaceus*, the last of the series described in the Observationes, and a member not of the first, but of the sixth, of the modern genera included by Fries in his first *Hypochnus*. But *H. olivaceus* is the type also of the later genus *Coniophorella*; then although by description Karsten's *Hypochnus* is the rough-spored group treated under the same name by Burt, by inevitable typification it is synonymous with, and takes precedence over, the smooth-spored, cystidiate *Coniophorella*.<sup>3</sup> *Hypochnus* in the sense of

<sup>3</sup> An additional complication is introduced by Bresadola's observation (3) that Fries's herbarium contains both a smooth- and a rough-spored *H. olivaceus*. Bresadola would blow hot and cold from the same mouth by considering each fungus *H. olivaceus* Fries, as though the other did not exist. But clearly there can be but one *H. olivaceus* Fries; an incongruous specimen must stand as evidence of a misdetermination. As described in the Observationes, the species in question is "*olivaceus*, *marginem fimbriato albedo*"; when next described by Fries, in the Elenchus, it was characterized



Patouillard (18) is defined even more clearly than Karsten's but quite differently: "Hymenium ténu, floconneux, tomenteux ou subpulvérulent . . . spores ovoïdes, lisses, incolores"; his first species is *H. serus*, the same as, or at least approximately homonymous with, Fries's first. But just as Karsten's definition was broad enough to include such alien species as *H. fumosus*, so Patouillard's was readily applied to fungi as different as *H. longisporus* (a highly characteristic *Peniophora*) and *H. Solani* (*Botryobasidium*).

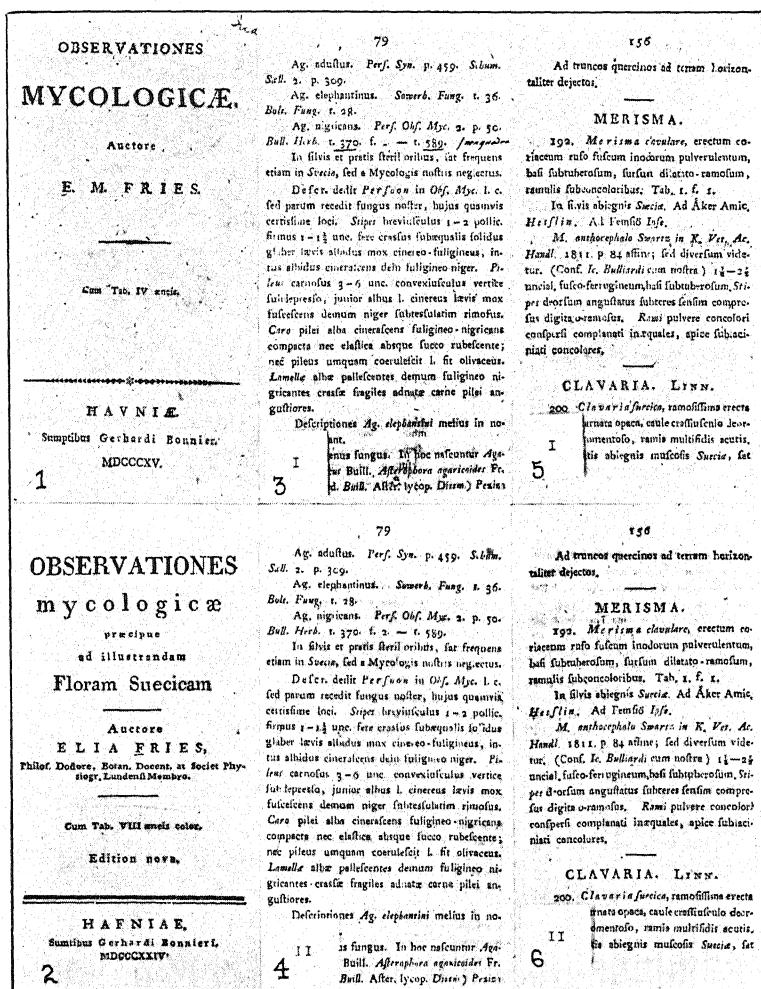
All these then are the genus *Hypochnus*. The recent incorporation into the International Rules of the type concept affords the possibility of a final solution of this tangle—and also of more nomenclatorial confusion in connection with *Hypochnus* than ever arose from anyone's "academic scheme"; and the possibility has already been seized upon. The proposal (4) to conserve *Hypochnus* with the type fixed as "*H. serus* Fr." <sup>4</sup> must, if accepted, inevitably lead to such wholesale name-changing as to eclipse completely the timid revisions of O. Kuntze and N. J. McGinty. For the species generally considered to be *H. serus* <sup>5</sup> has in its hymenium sterile bodies which Bourdot consistently considered to be cystidioles, the proper ornament of a *Corticium*, and Burt, for equally cogent reasons, to be cystidia, the chief character of *Peniophora*. With *H. serus* the type of *Hypochnus* it would be neces-

also by "Setulae sparsae; obscuriores." Neither description applies to any rough-spored form at present known; both describe *Coniophora* (or, *Coniophorella*) *olivacea*, which must consequently be presumed to be *H. olivaceus*. Whatever Karsten thought about the matter, then, Fries's *Hypochnus*, emendavit Karsten, whose type is Fries's *H. olivaceus* (i.e., *Thelephora olivacea* Fries ex Persoon, Myc. Eur. 1: 143. 1822; Fries, Elenchus 1: 197. 1828) is typified by a *Coniophora* (*Coniophorella*). This kinship of *H. olivaceus* with *Coniophora* seemed probable to Persoon also, as long ago as 1822 (l.c.).

<sup>4</sup> *Thelephora sera* Persoon, Myc. Eur. 1: 151. 1822. *Hypochnus serus* (Persoon) Karsten, Myc. Fenn. 3: 320. 1876 (*T. sera* Persoon, Syn. Meth. Fung. 580. 1801. *H. sereus* Fries, Obs. Myc. 2: 278. 1818). *T. bombycina* Sommerfeldt ex Fries, Elench. 1: 211. 1828. . . . Thus there was no *H. serus* published by Fries, unless *sereus* be regarded as one of his lesser lapsus calami.

<sup>5</sup> The uncertainty whether *H. serus*, necessarily based on Persoon's *Thelephora sera*, is the fungus usually identified with *H. serus* (i.e., *Corticium serum* sensu Bourdot & Galzin, *Peniophora Sambuci* sensu Burt) or that commonly known as *Corticium bombycinum*, scarcely recommends this proposal as a step toward nomenclatorial stability.

sary for those who see it as did Bourdot to transfer to *Hypochnus* the two hundred or so described species of *Corticium*, while for those who agree with Burt, *H. serus* would attract unto itself an



FIGS. 1-6.

equally extensive series of forms out of the then synonymous genus *Peniophora*. Be it noted that such a solution of the problem of *Hypochnus*, while it arbitrarily disposes of all the conflicting earlier conceptions by invalidating them, can itself scarcely be

clarified by legislation; it is to be hoped that no congress will ever set itself to decide whether the cystidioles of *H. serus* are cystidia or not. In America the prevalent idea of *Hypochnus* is Burt's, which, like Karsten's from which it is derived, sets this off from other thelephoraceous genera "by strictly resupinate habit [and] . . . by rough-walled to echinulate spores." Except that a too rigorous application of this definition has brought into the genus species wholly unrelated to the majority of its components (*H. Peniophoroides* Burt, *H. Tulasnellodeus* (Höhnelt & Litschauer) Rea), this is a good, practicable grouping. Also, it may, on the ground of usage, claim support of those to whom usage is tremendously important and for whom American usage is alone definitive. It so happens that there are several usages, of which this is but one, as a consequence of which situation conformist and recusant alike must appeal to the Rules; and it so happens that from the standpoint of the rules the name *Hypochnus*, applied to this or to any group of fungi, is indefensible.

As Donk (7) points out, and as Burt's citation (5) barely fails to indicate, these applications of *Hypochnus* to fungus genera depend for their validity on the existence of a second edition of Fries's *Observationes mycologicae*, published in 1824 and so not invalidated, as is the 1815-1818 edition, by the rule that nomenclature for the Hymenomycetes does not go back of 1821. Pritzel (19) is the first to refer to such an edition; he gives a citation as minutely circumstantial as that of the first edition, dating the two volumes 1824 and 1828. Lindau & Sydow (17) and Burt cite the work with equal confidence; but it appears that their authority is Pritzel, rather than actual examination of the volume. On the other hand Krok (15) reports his failure to find such a book in any of the great European libraries, and Donk (7) writes, "*eine Ausgabe aus dem Jahre 1824 . . . gibt es nicht!*"—italics and exclamation point being equally his. Enquiries directed by the writer to Miss E. M. Wakefield, Dr. J. H. Barnhart, and others brought further expressions of doubt concerning the existence of this nomenclatorially valid edition, and for a time it appeared to be probably no longer in existence. But finally a copy was discovered, in the library of the Massachusetts Horticultural Society, and borrowed for examination. The title-page of the first volume reads

as in Pritzel: "Cum tab. VIII aeneis color. Edition nova . . . MDCCCXXIV." The extraordinary thing is that apparently all that is new about the edition is the title-page; for the pages of the text are minutely identical—not as they would be if the first edition had been closely followed in setting up the second, but as they could be only when printed from the same individual types. To illustrate, from photographs of pages from the two editions: Volume I, p. 79 (FIG. 3, 4)—1. 6: *u* in *Bull.* is raised above the line; the lower left-hand corner of *H* in *Herb.* is cut off; 1. 7: the second *i* in *sterilioribus* scarcely has made an impression; 1. 12: *fi* in *firmus* is short at the bottom; p. 156 (FIG. 5, 6)—1. 5: *riac* in *coriaceum* is slanted below the rest of the line, as is *m* in *pulverulentum*; 1. 7: *b* in *Tab.* is above the line; 1. 8: *e* and the second *i* in *abiegnis* are weak, and *S* in *Sueciae* is cut off at the bottom; 1. 15: the second *t* in *digitato* is weak; 1. 21: *s* in *ramis* has the upper curve closed, as in a figure 9. Equally exact correspondences between the two editions occur wherever they are sought, in both the first and the second volumes. Thus in volume II, p. 280—1. 5: *s* in *sco* is raised above the line; 1. 9: only the *P* in *Pulchra* is an italic letter; 1. 19: *l* in *Theleph.* is an italic letter. So much for the text. The original title-page of volume 1 of the first edition (FIG. 1) is printed, as it should be, on the same paper used throughout the volume; that of the second edition is on paper of approximately the same color, but thinner and softer, and therefore could not be taken, even in the absence of the evidence already presented that the associated text was printed years before the date of the title-page, to be an original part of the volume into which it is bound.<sup>6</sup> Furthermore,

<sup>6</sup> According to the custom of the time, the printer in setting up the work commenced not with the first printed page, but with the first page of the body of the text; the title-page and any prefatory material were left until the end, to be printed if possible on any blank portion of one of the last sheets. Apparently there was at first no prefatory material for the *Observationes*; and apparently the single leaf bearing the title-page was printed on the sheet next to the last, for the gathering folded from that sheet, signature O, has only fourteen pages, 209–222, while all the others have the full sixteen (eight leaves). In the copy in the Farlow Library the title-page here illustrated (FIG. 1) is inserted immediately before signature A, and printed on the same paper as the rest of the volume. A copy in the writer's library, similarly dated 1815, must represent a later state, to which certain prefatory material was added: on its title-page appears a somewhat fuller text than on the original; following are a page of dedications, a

the original title-page of volume II of the *first* edition is bound into the *second* in its proper place, still bearing the date 1818. Probably Pritzel, in dating volume II of the second edition 1828, was attempting to correct this 1818; there is no apparent reason why the two volumes of the second edition, if this were such a one, should not be issued together.<sup>7</sup> The plates of the "second edition" are not actually eight colored, but four colored and four not, as in the first. A copy in the Lloyd Library of the second edition, from which photographs of certain pages were compared with the first edition, shows the same minute correspondences already described (and the same title-page as the Massachusetts Horticultural Society copy), and is therefore a second example of this incomprehensible reissue. As yet no report has appeared of the attitude of the International Botanical Congresses with respect to the nomenclatorial legitimacy of a work reissued with a new title-page bound in; for the present it is permissible to regard the second edition as invalid. One curious aspect of the matter is that personal notes of Dr. Farlow's, inside the front cover of his copy of the first edition, establish that the Massachusetts Horticultural Society's copy of the second, with which he had compared it, existed in its present form earlier than 1873, long before there was any attempt to fix on 1821 as a starting-point, and before the publication of Pritzel's note. The advantage of producing a spurious first edition is clear enough to any bibliophile; but a spurious second—! Another oddity occurs on the substituted title-page; possibly by someone a hint can be derived from the (presumably) inadvertent substitution of "edition" for "editio."

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promise of the early appearance of the second volume, and three pages of errata; all of this makes up a gathering of two pairs of leaves bound in to replace the original title-page; this gathering is printed on thinner, softer, yellower paper than the rest of the volume. The title-page of volume I of the "second edition" (FIG. 2) is a single sheet, bound in as was the original; difference in paper shows that it was not printed with the rest of the volume, in the place provided, along with the seven leaves of signature O. The text was printed in 1815; this title-page, presumably in 1824.

<sup>7</sup> The Friesian bibliography edited by Elias Fries's sons (13) gives the single date 1824 for an "ed. nova." If, as here suggested, Pritzel's 1828 should be 1818, his citation is of just such a patched-up affair as is here described. Whether T. M. & R. Fries examined the title-page of volume II does not appear in the record.

Whatever the story of the book, it is clear that Pritzel's second edition exists, and that it is as useless as the first for the purpose of establishing *Hypochnus* in a sense acceptable to anyone. Karsten's so-called emendation of 1881 (14), whether seen in the light of the type concept or treated more tenderly, as when it constituted the basis for Burt's work, must then fall. For neither here where it would bolster up the prejudice of a professional mycologist, nor where it is done apologetically to make the work of mycologists acceptable to the mycologically unlearned, is it strictly permissible to typify an ancient genus by a species quite unrelated to any of those included in the original valid publication. It is manifestly impossible to emend *Hypochnus* of the *Systema*, a genus composed, so far as known, exclusively of lichens, so as to make it tenable for Thelephoraceae. If emendations have nomenclatorial validity, the one published by Fries himself in the *Epicrisis*, where the lichen members of an enlarged *Hypochnus* are set apart as *Genuini*, would surely have precedence over Karsten's; if the emendation were to be (even though it cannot be) a recasting of the nomenclatorially non-existent *Hypochnus* of the *Observationes*, Bonorden's much earlier treatment (1), lacking species of *Hypochnus* as defined by Karsten and Burt, might well take precedence over Karsten's. . . . Here then is the present legal status of the name; any attempt to give it standing by conservation would seem to be scarcely profitable; the name already means so many things that it means nothing. Clearly the best procedure would appear to be that already informally recommended by Miss Wakefield, to consider *Hypochnus* a nomen ambiguum, in accordance with the Rules, and to put it permanently beyond the reach of misguided attempts at conservation or revival. Even though the 1824 "publication" were declared legitimate, no other way out of the tangle could be found as satisfactory as this.

There remains the question of the correct name for the fungi treated by Burt under *Hypochnus*. *Tomentella* Patouillard is clearly valid—and as the Hymenomycetes are now treated, is valid irrespective of the ultimate disposition of *Hypochnus*, so long as the latter is not deliberately conserved against it; *Tomentella* is valid without the conservation proposed by Donk (7). But the genus *Caldesiella* is properly not separable from *Tomentella*; in

any natural arrangement of the fungi the two must be regarded not as members of two distinct families, Thelephoraceae and Hydnaceae, but as only slightly different aspects of a single genus; *Caldesiella* is clearly more closely related to some species of *Tomentella* than are other Tomentellae. *As matters now stand*, then, *Tomentella* should be reduced to synonymy under the earlier *Caldesiella*. But this is exactly what should not be done; not only is *Tomentella* a large genus and *Caldesiella* a small one, but in addition *Caldesiella* will for some time be regarded by many as a member of the Hydnaceae; to treat the Tomentellae under this name would lead to further confusion.

In order "to avoid disadvantageous changes in the nomenclature of genera by the strict application of the Rules" (4), it is therefore hereby proposed to conserve *Tomentella* Patouillard 1887 (Type: *T. ferruginea*) against *Caldesiella* Saccardo 1877. Such conservation of course in no way affects the status of *Caldesiella* as an autonomous genus; for those mycologists to whom it is distinct, *Caldesiella* retains its name; since the two genera do not have the same type, the reduction of either to synonymy can proceed only from taxonomic, not from nomenclatorial, considerations.

To summarize: An 1824 edition of Fries's *Observationes mycologicae*, in which *Hypochnus* is sometimes thought to have been validly published, is spurious; the two copies extant are specimens of the 1815-18 edition with a new title-page tipped in. The valid publication of the genus is that in the *Systema mycologicum*; and this *Hypochnus* is composed of lichens. The name *Hypochnus* is then not available for any of the various groups of fungi to which it is applied. *Hypochnus* Fries emendavit Karsten is *Coniophora* or *Coniophorella*; *Tomentella* is the valid name for *Hypochnus* sensu Burt; *Peniophora* or *Corticium* for *Hypochnus* sensu Patouillard; *Hypochnus* of other authors is incapable of polite characterization.

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## EXPLANATION OF FIGURES

Photographs of pages from Fries's *Observationes*. FIG. 1, 3, 5, from Ed. 1, vol. 1, copy in the Farlow Library. FIG. 2, 4, 6, from Ed. 2, vol. 1, copy in the library of the Massachusetts Horticultural Society.



## ISOPLANOGAMETES IN BLASTOCLADIA

ERNST A. BESSEY

*Blastocladia* has been considered by some students of the genus as lacking sexual reproduction. On the other hand Butler (1) and Kanouse (3) considered the thick-walled resting spores to be oogones, perhaps parthenogenetic in function. The latter author described an antherid-like structure at the end of a slender filament and considered it to be a true antherid.

The writer in October 1935, obtained numerous colonies of *Blastocladia Pringsheimii* Reinsch by suspending fruits of *Rosa* and *Crataegus* in the Red Cedar River and in a pool in the Beal Botanical Garden, both on the campus of Michigan State College. This is the commoner species obtained in this manner but *B. globosa* Kanouse is also found some autumns. The colonies appeared as grayish tufts on the surface of the fruit, 0.1 to 0.5 mm. in diameter and height. Each such tuft consisted of many plants whose branches were more or less entangled, all embedded in a bacterial slime. When the fruits were washed under a rather strong stream of tap water most of this slime was removed and the colonies were picked off for study and mounted in distilled water. Numerous plants of various sizes showed an abundance of the thin-walled sporangia and a few plants showed numerous thick-walled sporangia (resting-spores of some authors). The plants bearing the thick-walled sporangia were in all cases smaller than those bearing the thin-walled ones. No plants were producing both types of sporangia. After a few minutes active swarm-spores began to be visible in the thin-walled sporangia and quickly emerged. No swarm-spores developed in the thick-walled sporangia under observation.

The escaping swarm-spores swam in all directions but soon began to approach one another in pairs. Because of the entangled plants it was impossible to determine whether the two forming each pair came from different plants or from the same plant. Many such pairs were observed. The beginning of fusion was

observed in several cases and in one case the process was followed until fusion was completed. The pairing cells came in contact laterally, not apically or at the flagellate end. A serious illness prevented the writer from following the fate of the united cells. In 1936, 1937 and 1938 *Blastocladia* was obtained again but in only one case were swarm cells observed and these did not show any signs of pairing.

In view of the fact that the very closely related genus *Allomyces* shows sexual union by heteroplanogametes (2, 4), this occurrence of isoplanogametes in *Blastocladia* is not surprising. Many things remain to be studied: Does any such alternation of sexual and non-sexual stages occur as in *Allomyces*; what environmental conditions favor this union, etc.?

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## THE HOST RANGE OF SAPROLEGNIA PARASITICA<sup>1</sup>

WESLEY N. TIFFNEY<sup>2</sup>

(WITH 2 FIGURES)

Although various species of the Saprolegniaceae have been reported on many different fish, in no case has the host range of these species of fish mold been determined experimentally under controlled conditions on an extensive series of accurately identified hosts. A survey of the literature on the subject discloses that although a composite host range can be compiled from the several references, such a host range is based not upon controlled experiments and accurate determinations but merely upon random records of various hosts parasitized by species of the Saprolegniaceae. Because these reports are numerous and most of them are of little value unless compared with others, the essential facts of the pertinent observations they contain are presented in Table I. It is true that a few writers (Smith, 23; Stirling, 24; and Clinton, 7) have reported infections appearing on large numbers of fish but these reports lack definite certainty of the identity of the parasite, while in nearly every case the host is mentioned by its common name, a practice which is confusing since one species of fish is often known by different common names in different regions.

It seemed desirable, therefore, by means of extensive inoculations under controlled conditions, to investigate the host range of

<sup>1</sup> Contribution from the Laboratories of Cryptogamic Botany and the Farlow Herbarium, Harvard University no. 167.

<sup>2</sup> The writer wishes to acknowledge his indebtedness to Professor William H. Weston, Jr., under whose direction this work was done, for his invaluable encouragement and guidance, and to Dr. David H. Linder, who made many helpful suggestions during the course of the investigation. The writer is also greatly indebted to Dr. O. E. Sette, Mr. R. A. Nesbit and Mr. R. A. Goffin, of the U. S. Bureau of Fisheries; to Mr. Arthur Kitson of the Massachusetts State Fisheries; and to Mr. O'Brien of the Boston City Aquarium, for their generous services in aiding the writer in collecting and for providing aquarium facilities for the fish used in these studies.

TABLE I  
HOST RANGE OF THE PARASITIC MEMBERS OF THE SAPROLEGNIACEAE COMPILED  
FROM PREVIOUS REPORTS

Author	Ref- erence num- ber	Parasite	Host
Agersborg, H. P. K...	(1)	<i>Saprolegnia ferax</i>	<i>Salvelinus fontinalis</i>
Bangham, R. V.....	(2)	<i>S. parasitica</i>	Large mouth black bass, small mouth black bass
Bennett, J. H.....	(3)	<i>Saprolegnia</i> sp.	Goldfish
Berkley, M. J.....	(4)	<i>S. ferax</i>	Fish eggs
Blanc.....	(5)	<i>S. ferax</i> or <i>Achlya</i> <i>prolifera</i>	Pickereel
Chiappelli, R.....	(6)	<i>Saprolegnia</i> sp.	Carp
Clinton, G. P.....	(7)	<i>S. ferax</i> or <i>S. mixta</i>	Small mouth black bass, rock brook trout, catfish, buffalo fish, dogfish, paddle fish, moon eye, gars, suckers, black bass, white bass, yellow bass, calico bass, yellow perch, grayling, pike, pike perch, sheepshead, sand pike, bream, blue sun- fish, warmouth
Graff, P. W.....	(8)	<i>S. parasitica</i>	Carp
Lund, A.....	(14)	<i>S. parasitica</i>	<i>Leusicus</i>
Murray, G.....	(15)	<i>S. ferax</i>	Salmon
Patterson, J. H.....	(16)	<i>Saprolegnia</i> sp.	Salmon
Robinson, E. M.....	(19)	Fish mold	Salmon fry
Rosenberg, A.....	(20)	Fish mold	Brook trout
Ryder, J. A.....	(21)	Fish mold	Shad ( <i>Alosa sapidissima</i> )
Schnetzler, J. B.....	(22)	<i>Achlya prolifera</i> and <i>Saprolegnia</i> <i>ferax</i>	Pickereel
Smith, W. G.....	(23)	<i>S. ferax</i>	Trout, eels, lampreys, floun- ders, minnows
Stirling, A. B.....	(24)	Fish mold	Roach, dace, godgeon, pike perch, perch, salmon
Unger, F.....	(26)	Fish mold	Tadpole, bull pout
Walentowicz.....	(27)	<i>Achlya Nowickii</i> and <i>Saprolegnia</i> <i>monoica</i>	Carp

one of these Saprolegniaceous pathogens, to determine the factors influencing infection, and to ascertain the resulting symptoms of disease on the various hosts.

The pathogen used was a sub-culture from the type of *Saprolegnia parasitica* Coker. This species was chosen because it had been found by the writer to be the most serious pathogen to fish in this region (Tiffney, 25) and also because the use of the sub-culture of the type eliminated all possible question of the identity of the parasite.

Fish and amphibians of as many different species as possible were obtained for use as hosts. A list of these animals and the sources from which they were obtained is given in Table II. The

TABLE II

THE SPECIES OF TELEOSTEI AND AMPHIBIA USED IN EXPERIMENTS TO DETERMINE HOST RANGE, WITH THE LOCALITIES FROM WHICH THEY WERE OBTAINED

Family species <sup>3</sup>	Common name	Locality
TELEOSTEI		
Siluridae		
<i>Ameiurus nebulosus</i> Le Sueur	Catfish	South Weymouth, Mass.
Catostomidae		
<i>Erimyzon sucetta</i> Lacépède	Sucker	South Weymouth, Mass.
Cyprinidae		
<i>Crassius auratus</i> L.	Goldfish	Boston, Mass.
<i>Semotilus atromaculatus</i> Mitchill	Dace	Guilford, Conn.
Anguillidae		
<i>Anguilla chrysypa</i> Rafinesque	Eel	South Weymouth, Mass.
Salmonidae		
<i>Salmo irideus</i> Gibbons	Rainbow trout	Nashua, N. H.
<i>Salmo fario</i> L.	Brown trout	Nashua, N. H.
<i>Salmo sebago</i> Girard	Salmon	Nashua, N. H.
Poeciliidae		
<i>Fundulus heteroclitus</i> L.	Chub	Boston, Mass.
<i>Lebistes reticulatus</i> Peters	Guppy	Boston, Mass.
Esocidae		
<i>Esox reticulatus</i> Le Sueur	Pickarel	Falmouth and South Weymouth, Mass.
Centrarchidae		
<i>Pomoxis sparoides</i> Lacépède	Calico bass	Falmouth, Mass.
<i>Eupomotis gibbosus</i> L.	Sunfish	Falmouth, Mass.
<i>Micropterus salmoides</i> Lacépède	Black bass	South Weymouth, Mass.
Percidae		
<i>Perca flavescens</i> Mitchill	Yellow perch	Falmouth, Mass.
Serranidae		
<i>Morone americana</i> Gmelin	White perch	Falmouth, Mass.
AMPHIBIA		
Salamandridae		
<i>Triturus viridescens</i> Rafinesque	Newt	Rindge, N. H.
Ranidae		
<i>Rana pipiens</i> Schreber	Frog	Lexington, Mass.

fish were taken from their native waters by means of seines and transported in cooled, insulated tanks to the aquaria at the Boston City Aquarium or at the Harvard Biological Laboratories in Cambridge. During the course of the experiments the fish were kept in isolated tanks which were supplied with a constant flow of water. The chubs and other small fish were kept in 6" battery

<sup>3</sup> Teleostei determined and arranged after Jordan and Evermann (11, 12); Amphibia after Pratt (18).

jars, the somewhat larger fish in aquarium tanks  $16'' \times 8'' \times 10''$ , while the bass and other very large active fish were kept in concrete tanks  $2\frac{1}{2}' \times 4\frac{1}{2}' \times 2\frac{1}{2}'$ . Since it was found that the Cambridge municipal water was toxic to trout and salmon, experiments on these fish were conducted at the Boston City Aquarium.

Inoculation of the fish was accomplished by inducing the parasitic *Saprolegnia* to form large numbers of zoöspores in the tanks. Zoöspores were produced at the outset of the experiment by using the method advocated by Klebs (13), Pieters (17) and others, which consisted essentially of growing the fungus for three days or more in a nutrient solution (0.5 per cent aqueous solution of peptone) until mats of mycelium were produced, washing these thoroughly to remove all adhering nutrient, and placing them in the fish tanks. This treatment resulted in the production of enormous numbers of zoöspores in a very short period of time. Continual zoöspore production was accomplished during the course of the experiment by placing hemp seed inoculated with the fungus in the tanks at intervals of three days. Thus the fish were thoroughly subjected to the possibility of infection, by continuous exposure to a larger number of zoöspores than would normally be found in nature. Since infection in nature is normally accomplished by zoöspores, as will be shown in a subsequent paper, this procedure gave what was considered to be a valid test of the susceptibility or immunity of the hosts.

Each experiment was carried on over a period of two weeks. As soon as an animal died from the disease it was removed from the tank, the identity of the parasitic fungus was verified by comparison with the type culture, and the death was recorded. In order to determine the part played by injury in susceptibility to infection, experiments were performed both on uninjured fish and on fish that had been injured by the removal of a few scales.

For the purpose of maintaining a control for each experiment, several fish were placed under the same conditions as the experimental fish but were not exposed to fungus. If at any time during the course of the experiments the fish in these control tanks appeared abnormal, possibly because of toxic substances in the tap water or because of some other undetermined agent, the experiment in progress was stopped and repeated on a new group of

fish. It was of course appreciated that spores of *Saprolegnia parasitica* or some other species of *Saprolegnia* or *Achlya* could come through the tap water and parasitize the fish. However, since the fish were subjected to heavy overdoses of *Saprolegnia parasitica* zoöspores and since the writer always verified the identity of the fungus recovered from the diseased fish by comparing it with that used in inoculation, the possibility of a species other than *S. parasitica* parasitizing the fish was practically excluded; and if, as is extremely improbable, *S. parasitica* did come in through the tap water from outside rather than from the thousands of zoöspores in the tanks, it did not vitiate the experiment.

The degrees of susceptibility shown by various species of hosts are presented on a percentage basis in Table III. These figures represent the incidence of death caused by the disease, and in most cases were compiled from observations on 25 or more individuals. However, in the cases of *Erimyzon sucetta*, *Anguilla chrysypa* and *Esox reticulatus* only 10 individuals of each could be obtained, while only 5 individuals each of *Pomoxis sparoides* and *Micropterus salmoides* were available.

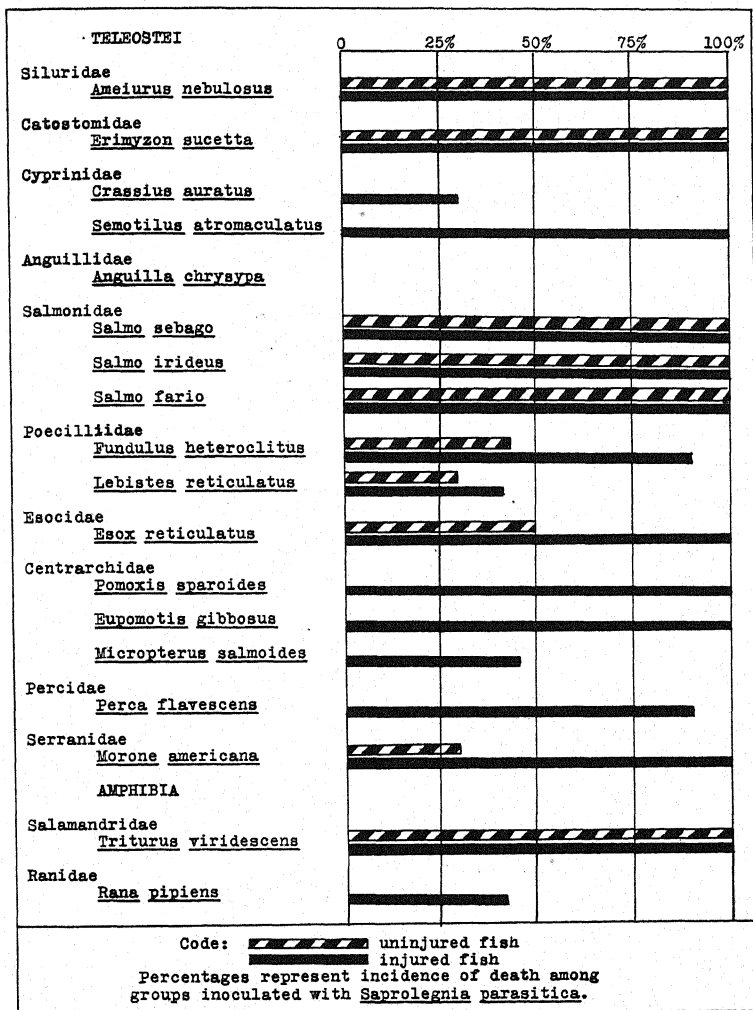
#### DISCUSSION

An examination of the results presented in Table III brings out certain points of interest. First, it is evident that the parasite was capable of attacking a wide range of hosts, for it parasitized frogs and salamanders as well as fish of nine different families. There was, however, a marked difference in the resistance of different species to the disease. For instance, *Ameiurus nebulosus*, *Erimyzon sucetta*, *Esox reticulatus*, *Triturus viridescens* and the species of the Salmonidae used, apparently had a very low resistance to this disease; *Semotilus atromaculatus*, *Pomoxis sparoides*, *Eupomotis gibbosus*, *Morone americana*, *Perca flavescens* and *Fundulus heteroclitus* showed a somewhat greater resistance; while *Crassius auratus*, *Lebistes reticulatus*, *Micropterus salmoides* and *Rana pipiens* had a rather high resistance to the disease. Only *Anguilla chrysypa*, of all the animals used, might be said to be immune to the fungus, for this fish, even when injured, did not contract the disease. This last finding at first might seem to be a direct contradiction of that of Smith (23), who

observed *Saprolegnia ferax* parasitizing eels in England. However, since it is now believed that the European eel and the American eel are different species, and since the parasite found by

Table III

The host range of *Saprolegnia parasitica* and the effect of injury on the susceptibility of the host.



Smith was *S. ferax* while the present writer worked with *S. parasitica*, the two cases are not necessarily contradictory, although they offer an interesting comparison.



Second, it is evident that injury greatly lowered the resistance of the majority of the fish to *S. parasitica*, a point of interest since fish under natural conditions probably sustain frequent injuries, particularly fish such as salmon which migrate up rivers to spawn. This effect of injury may explain the wide-spread epidemics observed by Huxley (9), Murray (15), and Patterson (16) among fish in the process of migrating to their spawning grounds.

The symptoms of the disease were identical on the various species of fish used in these experiments. The first indication of an infection was given by the behavior of the fish itself, which, evidently irritated, rubbed the infected region by vigorously swimming against some object. Even before the fungus itself was visible the infected area could be distinguished from the surrounding normal tissue by the abnormal protrusion of scales. The fungus appeared later as a small tuft growing in the center of this region, and the area increased in size as the fungus spread. It was noticeable that at about the time the infected area became 10 to 15 mm. in diameter the activity of the fish was lowered, and at the same time numerous other small infected spots appeared (FIGS. 1, 2).

During the second to fourth day after inoculation, depending upon the individual resistance to the disease, the trunk muscles seemed to become more and more paralyzed until the fish was incapable of moving its body and finally of moving even its fins, and in this state floated to the surface of the water or lay on the bottom of the tank. An autopsy showed that all internal organs appeared to be in a normal state and that the heart might still be beating. These latter observations are in accord with those made by Huxley (10).

Another point of interest is that the fish have been observed to eat living mycelial mats of *Saprolegnia parasitica*, and apparently suffer no harm from it. Agersborg (1) believes that fish suffer from intestinal infections of *S. ferax* brought about by eating the fungus. During the course of these experiments the present writer has repeatedly examined the intestines of fish that have eaten fungus. These examinations have been made from one to several days after infection might have occurred and although in some cases in gross appearance the intestinal contents somewhat

resembled hyphae, microscopic examination showed that there was no intestinal infection by *S. parasitica*.

It is of further interest to note that death was not due to smoth-

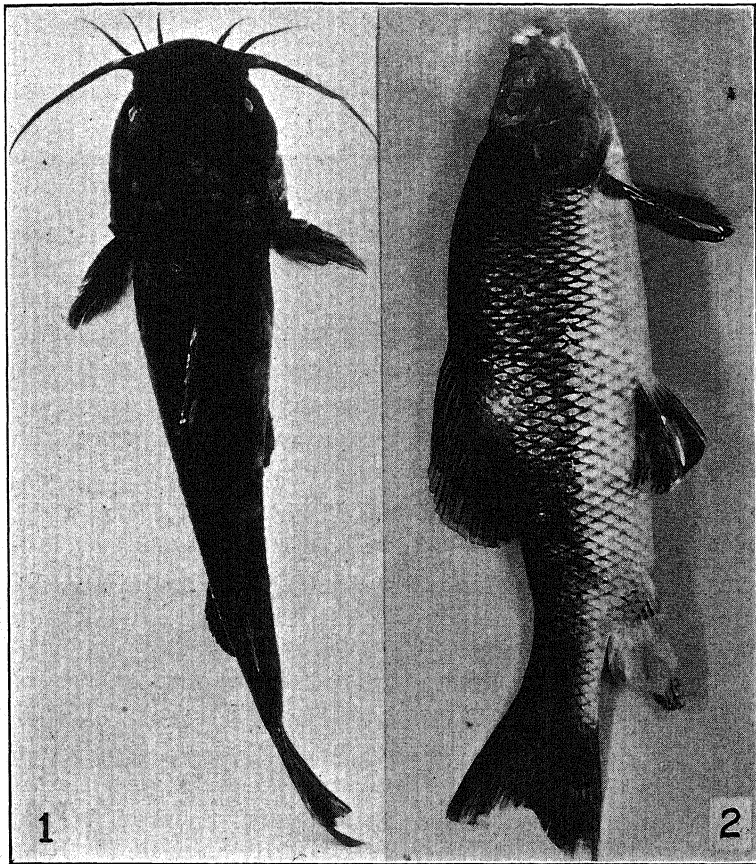


FIG. 1. *Ameiurus nebulosus*, showing the extent of infection four days after inoculation with *Saprolegnia parasitica*. Note the sharply defined circular lesions, characteristic of the disease on this host. ( $\frac{1}{2}$  natural size.)  
 FIG. 2. *Erimyzon sucetta*, showing the extent of infection with *Saprolegnia parasitica* four days after inoculation. Note the raised lesion just under the dorsal fin, and also the lesions on the head, tail fin and anal fin. ( $\frac{1}{2}$  natural size.)

ering. In all the cases observed by the writer there has been but one instance in which the hyphae of the parasite grew on the gills of the host. This was an exceptional epidemic among *Necturi*

following injuries received during shipment, an epidemic so severe that the fungus, in contrast to its usual occurrence in small patches, completely covered the animals. Moreover, the symptoms of smothering, according to the writer's observations, were different from the symptoms of the *Saprolegnia* disease since fish undergoing asphyxiation continually came to the surface of the water for oxygen and might in extreme cases rapidly dash back and forth at the surface of the water. Such actions were never observed in the case of fish infected with *Saprolegnia parasitica*. The writer's conclusion that death was not due to smothering is in agreement with that of Huxley (10), who stated that he had never observed the parasite on the gills of fish.

The symptoms of this disease seem to indicate that there are three possible causes of death. First, the fungus may cause death by the destruction of tissues; second, some sort of toxic materials may be formed which cause paralysis and death; third, the fungus may destroy areas of protective epidermis, thus permitting free passage of water and in all probability causing dilution of body fluids in fresh-water species or dehydration of body fluids in salt-water types, and consequently bringing about basic isotonic upsets. It is the writer's purpose to discuss these three possibilities in subsequent papers.

Other authors (see Table I) have observed that members of the Saprolegniaceae are capable of parasitizing a large number of species of fish. However, as far as the writer knows, this paper gives for the first time the host range of one species of *Saprolegnia*, determined experimentally under controlled conditions on accurately identified hosts. It adds the following species of fish and amphibians to the list of hosts of *Saprolegnia parasitica* Coker: *Ameiurus nebulosus*, *Erimyzon sucetta*, *Crassius auratus*, *Semotilus atromaculatus*, *Salmo sebago*, *S. irideus*, *S. fario*, *Fundulus heteroclitus*, *Lebistes reticulatus*, *Esox reticulatus*, *Pomoxis sparrowoides*, *Eupomotis gibbosus*, *Micropterus salmoides*, *Perca flavescens*, *Morone americana*, *Triturus viridescens* and *Rana pipiens*.

#### SUMMARY

The host range of *Saprolegnia parasitica* Coker was investigated by means of controlled inoculations on accurately identified fish and amphibians of as many species as could be obtained.

1. It was found that there was a marked difference in the resistance of various species of hosts to the pathogen. *Ameiurus nebulosus*, *Erimyzon sucetta*, *Esox reticulatus*, *Salmo sebago*, *S. irideus*, *S. fario* and *Triturus viridescens* were found to have a very low resistance to the disease. *Semotilus atromaculatus*, *Pomoxis sparoides*, *Eupomotis gibbosus*, *Morone americana*, *Perca flavescens* and *Fundulus heteroclitus* showed a somewhat greater resistance, while *Crassius auratus*, *Lebistes reticulatus*, *Micropterus salmoides* and *Rana pipiens* had a high resistance to the disease. Only *Anguilla chrysypa* was found to be immune.

2. Injury greatly lowered the resistance of the majority of the species of hosts to the disease.

3. The symptoms of the disease were identical for the various species of fish used in these experiments.

4. Fish were frequently observed to eat living mycelial mats of *Saprolegnia parasitica* but apparently suffered no harm thereby and did not develop intestinal mycosis.

5. Except for one aberrant case, there was no evidence that the death of the host was caused by smothering.

6. From observations made during the course of this investigation the writer suggests three possible causes of death to the host: (a) the destruction of tissue, (b) the formation of toxic materials, and (c) the dilution or dehydration of body fluids resulting from the destruction of areas of protective epidermis.

7. The following species of fish and amphibians were added to the previous records of hosts of *Saprolegnia parasitica* Coker: *Ameiurus nebulosus* Le Sueur, *Erimyzon sucetta* Lacépède, *Crassius auratus* L., *Semotilus atromaculatus* Mitchell, *Salmo sebago* Girard, *S. irideus* Gibbons, *S. fario* L., *Fundulus heteroclitus* L., *Lebistes reticulatus* Peters, *Esox reticulatus* Le Sueur, *Pomoxis sparoides* Lacépède, *Eupomotis gibbosus* L., *Micropterus salmoides* Lacépède, *Perca flavescens* Mitchell, *Morone americana* Gmelin, *Triturus viridescens* Rafinesque and *Rana pipiens* Schreber.

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### MYCOLOGICAL NOTES. III

C. L. SHEAR

(WITH 1 FIGURE)

#### 10. SPHAERIA CONFERTA Schw. Syn. Fun. Car. 45, No. 187. 1822

Schweinitz described this species as follows:

187. *conferta* Sz.

*S. simplex aggregata globosa truncata subinculoque repente radiato-fibroso aterrimis.*

In cortice Lauri Benzoin emortuo leviter innascens. Subiculum e filis crassiusculis, stellatim in cortice repentibus; ubi sparsa occurrit sphaeria, eleganter centrum florum occupat. Sphaeriae confertae, truncatae, disco impresso, demum collapsio, ut in Sph. cupulari. Ostiolum minutum, deciduum. Sphaerulae granulosa.

In Syn. Fun. Bor. 211, No. 1508, 1832, he made the following record, changing the name:

1508. 363. *S. confertula*, L.v.S., Syn. Car. 187, F. 286 (*conferta*) rariter etiam in Pennsylv.

The exact identity of this species has been in doubt up to the present time. Cooke, Grevillea 15: 81. 1887, has the following note:

*Byssosphaeria (Amphisphaeria) conferta*, Schwein. Sacc. Syll. No. 4277. Herb. Berk. 9603.

Sporidia uniseptata, fusca, utrinque obtusa, medio constricta, .012 × .004 mm.

Whether the specimen referred to by Cooke as "Herb. Berk. 9603" is part of a Schweinitz specimen in the herbarium at Kew or not we do not know. In any case the description of the spores does not agree with any fungus found by others who have examined portions of Schweinitz' specimens, and the name used by Cooke can not be regarded as a synonym of Schweinitz' *Sphaeria conferta*. Schweinitz changed the name to *confertula* as indicated in Syn. Fun. Am. Bor. (l. c.) evidently because Fries in the interim between Schweinitz' two publications had described another species

of *Sphaeria* as *S. conferta* Fries, Syst. Myc. 2: 435. 1823, and for some unknown reason a few pages later (444) he also described Schweinitz' species of the same name. Fries' fungus was on leaves of *Vaccinium* and different from Schweinitz' plant.

Ellis, Proc. Phil. Acad. 1895: 25, describes a part of one of Schweinitz' specimens which is found in the Collins' collection of Schweinitz' fungi as *Trematosphaeria confertula* (Schw.). This specimen, however, is not a part of the type specimen from Salem, North Carolina, upon which the original description was based. We find on examination of the Collins' specimen that it is labeled by Schweinitz himself "Beth.," indicating clearly that it was a part of the material gathered in Pennsylvania and mentioned in his Syn. Fun. Am. Bor. (1. c.). This specimen, though somewhat similar in superficial appearance, is an entirely different species from the type collected at Salem, as will be shown below.

The next reference to Schweinitz' species is by Starbäck, Bot. Not. 1893: 28. 1893. He examined the specimen which Schweinitz had sent to Fries, but failed to find asci or spores, but said it was very similar in external appearance to *Sphaeria eumophala* Berk. & Curt. This specimen was probably part of the Salem material.

The next note we find on this species is by Farlow, Bibl. Index N. Am. Fungi 1: 214. 1905. He examined a part of a specimen of Schweinitz in the Curtis Herbarium at Harvard and said that the external resemblance to *S. eumophala* is marked, but the spores did not agree with those described by either Cooke or Ellis. Two kinds of spores were found, one free, dark colored, elliptic,  $8-9 \times 2.8 \mu$ , the other hyaline, acicular,  $14-16 \times 2.8 \mu$  in clavate asci.

Later Fitzpatrick, Mycologia 15: 55-57. 1923, discussed Schweinitz' species. He examined the specimen referred to by Farlow in the Curtis herbarium which was apparently a part of the Salem plant and found it to agree with *S. eumophala*. He also examined an autographed specimen of Schweinitz in the herbarium at the Philadelphia Academy, and states that it is the same as the Schweinitz specimen in the herbarium of Curtis. He found perithecia and free spores agreeing in size, shape and surface characters with those of *Sphaeria eumophala* Berk. & Curt., and also the hyphae of the subiculum were the same; but as he found no



asci he did not state positively that the two species are the same. We have examined the portion of Schweinitz' specimen found in the herbarium of Michener in the Mycological Collections of the Bureau of Plant Industry, and find not only free ascospores, but a few asci. The specimen agrees in every respect with *Sphaeria euomphala* Berk. & Curt. as shown by a comparison with the type specimen of the latter species.

We have also examined an autographed specimen of Schweinitz in Collins' herbarium referred to by Ellis (l. c.) which was collected at Bethlehem and which he called *Trematosphaeria confertula* (Schw.). This specimen, however, is really *Chaetosphaeria fusca* Fuckel, as we have determined by comparison with an authentic specimen of Fuckel's species in his *Fungi Rhenani*, No. 2041.

It is evident from the studies in this case that Schweinitz' original material from Salem, N. C., upon which he based his description was rather old and contained few asci, also that evidently mixed on the same specimen, as reported by Farlow (l. c.) and as is frequently the case in such material, were pycnidia or perithecia and spores of other fungi. We have also found free spores of other species on the specimen in Michener's herbarium. The fungus which Schweinitz described from Salem, however, is so characteristic in macroscopic and microscopic appearance, and agrees so well with his description, that there is no longer any reason to doubt that it is the same as *Nitschkia euomphala* (Berk. & Curt.) Ellis & Ev., N. Am. Pyren. 246, 1892.

Due to Schweinitz' practice, as we have pointed out before, of including different gatherings of what he regarded as the same plant in the same packet, different species were frequently mixed. Thus we find in this case that the second specimen collected at Bethlehem, though much the same in macroscopic appearance, belongs to an entirely different genus. There being no longer any doubt as to the synonymy of the original species, the question arises whether Schweinitz' specific name *conferta* should replace Berkeley and Curtis' name *euomphala* on the basis of *priority*. We do not think, however, that such a change would be desirable and it might be argued, as Farlow has done, that on account of the previous

confusion in interpretation of Schweinitz' species the name *conferta* should be left as a synonym.

In this connection we may add that we use the name *Nitschkia* instead of *Tympanopsis* Starbäck, as followed by Fitzpatrick (l. c.). As he says (p. 54) *Tympanopsis* differs from *Nitschkia* chiefly in its colored spores. The spores, however, when fully mature are only slightly colored, and the separation of genera on spore color alone leads to a very artificial rather than a natural classification.

#### 11. *Russula lilacipes* sp. nov.

Solitaria vel aliquantulus gregaria; pileo convexo usque umbilicato, 7-15 cm. diam.; superficie glabra, uda viscosa, sordida usque pallide flavidula; lamellis latis, subdistantibus, adnatis, pallide viride-flavidis vel flavidulis; stipite centrali, robusto, cylindrico, purpurascens; sapore miti; odore nullo; sporis albis, ovoideis vel subglobose, subtiliter verrucosis,  $7-7.5 \times 5-6 \mu$ ; cystidiis  $80 \times 8-9 \mu$ .<sup>1</sup>

Plants solitary or somewhat gregarious, rarely sub-caespitose; pileus broadly convex to nearly plane, soon becoming umbilicate or somewhat infundibuliform, 7-15 cm. in diameter; margin incurved when young, even; surface somewhat irregular, smooth, very viscid when wet, but with no separable pellicle, sordid or pale-yellowish or watery-cream color, somewhat suggesting in color wet specimens of *R. foetens*, paler when fresh and dry; flesh firm, compact, not changing color or only very slightly when wounded; lamellae broad, subdistant, some forked and a few short ones intermixed, adnate, arcuate toward the margin, pale greenish-yellow to pale-yellow, sometimes slightly changing to subviolaceous when wounded and becoming spotted and discolored when old; stipe central or occasionally somewhat eccentric, stout, cylindrical, smooth or somewhat pruinose, frequently irregular and somewhat pitted or ridged, solid, very firm, compact; at summit pale-yellowish pleroma-violet or bishop-purple to auricula-purple of Ridgway at the base and extending upward frequently to the middle or higher, sometimes distributed in dots and irregular spots; taste mild and pleasant; odor scarcely any, at least not unpleasant; juice none; spores white, ovoid to subglobose, delicately verrucose,  $7-7.5 \times 5-6 \mu$ ; cystidia somewhat clavate, acuminate, the pointed apex projecting beyond the basidia, mostly  $80 \times 8-9 \mu$ . (FIG. 1.)

Type: B. O. Dodge, Radnor Heights, Arlington, Va. (Shear No. 4058).

<sup>1</sup> Thanks are due to Miss Edith K. Cash for the preparation of this Latin diagnosis.

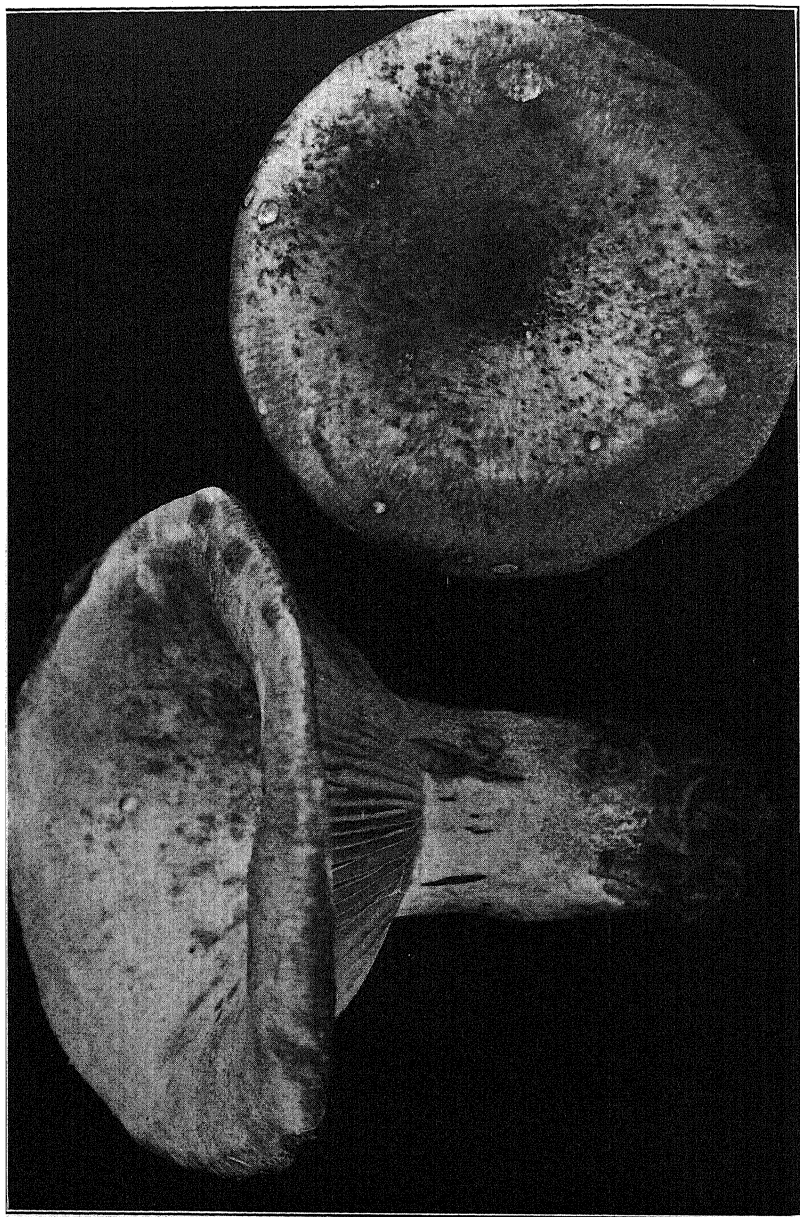


FIG. 1. *Russula lilacipes* nat. size.

Habitat: bare clay cellar bottom and bank, and road cut in woods Arlington Cemetery, Virginia, August 1, to September 17, 1922.

Five other gatherings have also been made in the latter place in August and September during the years 1926 to 1938. Specimens were also collected by R. W. Davidson in Clarendon, Va., Sept. 9, 1934.

Watery drops are found on the edge of the gills when the plants are young and fresh. This is apparently water of condensation rather than exudation, but where these drops dry the gills turn purplish.

This is a remarkable species in habitat, color, and texture. The specific gravity is greater than that of any other agaric we know. A single plant weighed 8 oz. In wet weather the pileus is frequently covered with clay brought up with it as the plant emerges and adhering to the viscid surface. The violet color mostly disappears in drying.

Dr. G. S. Burlingham and Prof. H. C. Beardslee have kindly examined specimens of this plant and have confirmed the opinion that it is undescribed. Prof. Beardslee suggests possible relationship to *R. ventricosipes* Peck which is similar in color but has a thin striate margin and different texture.

## 12. SPHAEROSPORIUM Schw.

This genus was described by Schweinitz in his Syn. Fun. Amer. Bor. p. 303, 1832. The volume of the Proceedings of the American Philosophical Society in which this paper appeared is dated 1834, but separates were published and distributed in 1832. The original description (l. c.) is as follows:

### Genus 229. *Sphaerosporium* L.V.S., Novum Genus

Sporidochiis oblitteratis planiusculis, strato densissimo, pulvinatim elevato incumbente sporidiorum non simplici sed coacervato. Sporidiis majoribus pellucidis, globosis, intus includentibus massam globulosam, grumosam, opacam.

× 3036. 1. *S. lignatile*, L.v.S., in frustulis majoribus pulveris vaporariae, et in corticibus putridis Quercuum, etiam Salicum, Bethl. S. strato pulvinato sporidiorum ex ochraceo rufo-pulvinatim super sporidochium elevato. Acer-vis 2-3 linearibus, aggregatis, ovatis, aut longissime confluentibus. Globulus exterior sporidiorum in aqua, omnino pellucidus; interior subopacus. Siccio

tempore tota sporidia tum subangulata, ochracea et opaca deveniunt. Acervos Bactridii primo obtutu refert.

A part of Schweinitz' original collection is found in Michener's herbarium in the Mycological Collections of the Bureau of Plant Industry. With this there is another specimen of Schweinitz' labelled *S. vaporarium*, a name he apparently first considered, but changed to *lignatile* before publishing. Both specimens are on decaying wood of *Quercus* and are identical. The spores are apparently normally globose when free, but very variable in shape and size in mass, where they press against each other. The globose forms are  $36-50\mu$  in diameter, the other forms  $38-66 \times 33-45\mu$  and the spore wall about  $6\mu$  thick. There are no signs of sporophores in the specimens examined, and the mode of development and production of the spores is not clear. Other authentic specimens are also at Philadelphia, Kew and Harvard. The species is rather easily recognized by the small pulverulent masses of honey colored, very thick walled spores. An excellent example is to be found in Reliquiae Farlowianae, No. 667 collected by Thaxter in Connecticut in 1889. The species is evidently not rare and is known to occur from Connecticut to Louisiana. We have collected it in Maryland and Virginia. There are specimens in the Mycological Collections from North Carolina deposited by F. A. Wolf, No. 433, and from Louisiana collected by Langlois.

Von Höhnelt discussing this genus and species, Frag. Myc. No. 674, pp. 402-403, 1911, comes to the conclusion that the genus is a synonym of *Coccospora* Wallr. Fl. Crypt. Germ. 2: 176, No. 1544. 1833. He states, however, that he had seen no authentic specimen of Wallroth's plant, and doubts whether any exists. From our comparison of Schweinitz' specimen with Wallroth's description it seems very doubtful whether the two fungi belong to the same genus, as Wallroth describes his fungus as usually oblong, cylindrical and smooth, and a beautiful orange color. When wet with water it dissolves into a mucilaginous mass, and when dry is covered with glutinate mucus. *Sphaerosporium*, so far as we have seen, always forms a low pulvinate mass of glistening, honey colored spores which are easily separated and do not dissolve into a mucilaginous mass.

*Protomyces xylogenus* Sacc. *Michelia* 1: 14. 1879, and Fung. Ital. fig. 104. 1877, is also believed by von Höhnelt to be, if not the same species, at least the same genus. He also states that *Bactridiopsis Ulei* P. Henn. *Hedwigia* 43: 397. 1904, according to the description belongs to the same genus and is perhaps identical with Schweinitz' species. Von Höhnelt's conclusions are based upon a comparison of descriptions and illustrations rather than authentic specimens, except in the case of *Protomyces xylogenus* Sacc. He compared specimens labeled *Coccospora aurantiaca* Wallr. collected by Bizzozero near Venice and a specimen so labeled by Bresadola collected by Fairman, Lyndonville, N. Y., 1904, and found them all the same. As a result of his studies he concludes that *Coccospora* should be adopted as the generic name of all the species mentioned, and *Sphaerosporium* Schw., *Protomyces* Sacc., p.p., *Bactridiopsis* P. Henn., and *Allescheriella* P. Henn. *Hedw.* 36: 244. 1897 regarded as synonyms.

In our opinion, however, as just stated, *Coccospora* Wallr. according to present available information is a very doubtful synonym of *Sphaerosporium* Schw., and in any case on the basis of priority Schweinitz' name, which, as we have pointed out, was published in 1832, instead of 1834 as usually cited, is older than Wallroth's 1833, and should be adopted. *Protomyces xylogenus* Sacc. and the Bizzozero and Fairman specimens mentioned above are probably Schweinitz' species and not Wallroth's *Coccospora*.

13. SPHAERIA GLEDITSCHIAE Schw. Syn. Fung. Car. 40, No. 131, 1822

Specimens of this species collected by Schweinitz have been examined with the following results. In Schweinitz' mounted collection at Philadelphia, there are two pieces both of which show micro- and macro-pycnospores of a species of *Sphaeropsis*. There is an occasional septate spore.

The specimen of this number, 1435, Schw. Syn. Fun. Am. Bor. in Michener's herbarium, consists of two parts and three pieces. The piece at the left is bark from a rather large branch, and bears the remains of a gummed strip of paper, such as was used by Schweinitz in mounting his early collections. This probably represents part of his Salem specimen upon which his original de-

scription (l.c.) was based. This specimen also agrees with the original description. It bears a few small closely packed groups of pycnidia which show chiefly free spores of *Sphaeropsis*.

The other two pieces at the right, probably part of the collection reported from Pennsylvania in Syn. Fun. Am. Bor. p. 206, No. 1435 as *S. Gleditsiae* (note change in spelling), are very similar in general appearance to the other specimen and show pycnidia and spores of *Sphaeropsis*, apparently identical with those from the other specimen. The pycnidia are mostly old and the spores free. Most of the spores are non-septate, but a few are septate. Minute hyaline microspores are present in separate pycnidia, and some free, 3-septate brown spores,  $10-12 \times 4-5 \mu$ , belonging to some other fungus, are also found on the slides.

There are two small packets in Schweinitz' original autographed collection at the Philadelphia Academy. These are the same *Sphaeropsis* and are perhaps part of the Pennsylvania specimen. The Collins set of Schweinitz' authentic specimens of *Sphaeria* also preserved at Philadelphia does not contain this species. It is evident from an examination of this material that the fungus described by Schweinitz under this name is a *Sphaeropsis*. In Seymour's Host Index, the synonymy is given as follows:

*Botryosphaeria Gleditschiae* (S.) Sacc.

*Cucurbitaria Gleditschiae* (S.) Berk. & Curt.

*Cucurbitaria recuperata* Theissen.

*Melogramma Gleditschiae* (S.) M. A. Curtis.

*Sphaeria Gleditschiae* S.

*Valsaria Gleditschiae* (S.) Ellis & Ev.

Curtis had a specimen of Schweinitz' No. 1435, and sent part to Berkeley, but did not make any note as to its identity.

Berkeley, in Grevillea 4: 47. 1875, refers Curtis' North Carolina specimens Nos. 841 and 942 to "*Cucurbitaria gleditschiae* Schwein." with the note "sporidia ovate uniseptate." According to Berkeley's copy of Schweinitz's Syn. Fun. Am. Bor., he had a specimen of *Sphaeria Gleditschiae* from Schweinitz' herbarium, but whether his identification was based upon a comparison with that specimen is unknown. A little later Berkeley (l.c. p. 98) refers a specimen of Michener, No. 3943, from Pennsylvania to

"*Melogramma Gleditschiae* Schwein." We can find no specimen labelled either *Melogramma* or *Sphaeria Gleditschiae* in Michener's herbarium with this number. There is, however, a specimen of Michener labelled "*Sphaeria Gleditschiae* Sz. ad ram. mort. *Gleditschiae*, London Grove, C. Co. (Pa.)" without number. This may be a part of the material sent to Berkeley, the number having possibly been added by Curtis who transmitted most of Michener's collections to Berkeley. Michener has added in pencil opposite this name in his catalogue of his herbarium, "*Melogramma*." The fungus is evidently the same as that represented by Schweinitz' specimens which we have seen. A few spores of *Sphaeropsis*, some occasionally septate, are found and also what appear to be young perithecia of *Physalospora* or *Botryosphaeria*, but no asci or spores are present.

Cooke, Grevillea 13: 109. 1884, puts Schweinitz' species in *Melogramma*, section *Valsaria*. He makes no statement as to specimens examined.

There is no evidence here that the above identifications of Berkeley and Cooke were based upon a comparison of type or authentic specimens of Schweinitz' species. In N. A. Pyren. p. 564, Ellis refers Schweinitz' species to *Valsaria*, citing Schweinitz' and Michener's localities. He evidently based his action on Berkeley and Cooke, as no spore measurements or other information is given.

Saccardo, Syll. Fung. 2: 310. 1883, under *Cucurbitaria Gleditschiae* Ces. & D'N. cites "*Cucurbitaria Gleditschiae* (Schwein.) Berk. N. Am. Fun.," quoting Berkeley's statement "sporidia ovata uniseptata" and adding "an *Othia*?" Saccardo Syll. Fun. 1: 463. 1882, under "Minus certae" has *Botryosphaeria Gleditschiae* (Schw.) Sacc., citing as a synonym "*Melogramma Gleditschiae* (Schw.) Berk. in Grev."

Theissen, Ann. Myc. 14: 333-335. 1916, proposes a new name, *Cucurbitaria recuperata* Theiss., for Schweinitz' fungus, citing as synonyms *Sphaeria Gleditschiae* Schw.; *Valsa Gleditschiae* (Schw.) Cooke, Grevillea 13: 109. 1884. (In this case, Cooke used *Valsaria* as a subgeneric name under *Melogramma*); *Melogramma Gleditschiae* (Schw.) Berk. Grevillea 4: 98. 1876; and *Botryosphaeria Gleditschiae* (Schw.) Sacc. Syll. Fung. 1: 463.



1882. He says he examined three collections from the herbarium at Kew, two numbers in Berkeley's herbarium, 922 and Fung. Carol. Inf. 942, the same as Berkeley mentions, besides an original specimen of Schweinitz. He says of the numbers 922 and 942, that the last is the best developed and shows mature asci with brown muriform spores and good paraphyses, but appears identical with the other undeveloped specimens, and that all are quite different from *Botryosphaeria*. He found asci in No. 942, short stipitate, p. sp.  $130-160 \times 12-15 \mu$ , containing 8 spores, which were 6-celled, often with longitudinal septa, dark rusty-brown,  $26-28 \times 13 \mu$ , constricted at the middle.<sup>2</sup> He says this differs in its smooth perithecia from *Cucurbitaria Gleditschiae* Ces. & D'N. which has rough warty perithecia, and also from *C. elongata* (Fries) Grév. which has a broadly effuse stroma. His discussion therefore throws little light upon the real identity of *Sphaeria Gleditschiae* Schw.

Fries, Syst. Myc. 2: 421. 1823, says of Schweinitz' species "the groups of perithecia are sparse, 1 line long or less." This statement is evidently based upon a specimen from Schweinitz, as he cited "V.S." (dried specimens) from Carolina.

According to the records so far, we find no statement that anybody has found asci in any of Schweinitz' specimens. Cooke may possibly have found the uniseptate free spores of *Sphaeropsis* which we have found in all the specimens of Schweinitz' collection examined. It seems fairly certain therefore that the fungus which Schweinitz described was a species of *Sphaeropsis*. It is, of course, possible that there may have been a few free spores of *Valsaria* or *Cucurbitaria* on some part of his specimens, as *V. insitiva* and *C. elongata* are not uncommon on *Gleditschia* in this region.

As a result of our studies we conclude that *Sphaeria Gleditschiae* Schw. is a *Sphaeropsis* and agrees with the very common species which has been widely known as *S. malorum* Peck, and has been shown to have a great number of synonyms (cf. Stevens, Myco-

<sup>2</sup> This is an entirely different fungus from that which Berkeley found on the same specimen No. 942 as cited and described as having ovate uniseptate sporidia. There is evidently more than one fungus present on this specimen as is not unusual.

logia 25: 543-546. 1933) and to have as its ascigerous stage *Physalospora obtusa* (Schw.) Cooke. Stevens also examined some of Schweinitz' collection of this species, and cites it as a synonym of *S. malorum* Peck (l.c. p. 544).

#### 14. DRYOPHILUM Schw.

This genus was described by Schweinitz, in Syn. Fun. Am. Bor. 268, 1832, with two species as follows:

Genus 143. *Dryophilum*, L.v.S., Novum Genus, an hujus loci? Peridium pezizaemorphum, sed omnino clausum, sessile aut papilla basilari stipitatum et folio affixum. Intus simile album. Extus vestitum cortice duriusculo.

2465. 1. *D. pezizoideum*, L.v.S., in foliis vegetis Quercus Banisteri et aliorum praesertim in montibus e.g. Mauch Chunk Coal mine. Etiam ex Georgia communicavit Leconte.

D. sparsum, cupulis 2-3 linearibus, orbiculatis, papilla basilari affixum, disco ime depresso nigrescenti. Cortice externo fibris crassiusculis densis arcte adpressis subtus albidis tecto, margine et extus eleganter spadiceo-sericeis.

2466. 2. *D. umbonatum*, L.v.S., etiam in folio querneo communicavit Leconte ex Georgia.

D. sparsum, minus, folio subinnatum, cortice exteriori non fibroso sed glabro, ex rufo splendente spadiceo. Disco in umbonem elevato. Vix lineam excedens diametro.

Parts of Schweinitz' specimens of the two species are in Michener's herbarium. Both are insect galls. The first, *D. pezizoideum*, has been identified by Mr. L. H. Weld, specialist in gall insects, as *Neuroterus* (*Neuropterus*) *umbilicatus* Bass. He says also that the host is not *Quercus Banisteri*, as given by Schweinitz, but *Q. bicolor*. The other species, *D. umbonatum*, had galls somewhat similar in appearance, but unfortunately this specimen was lost; but from the description and figures Mr. Weld is of the opinion that the galls were those of *Neuroterus saltarius* Weld, which occurs on the same host and also on *Q. macrocarpa*. Specimens of both these numbers are to be found in Berkeley's herbarium at Kew according to check marks in his copy of Schweinitz' work cited above. The only reference to this we find in Saccardo's Sylloge Fungorum is in 18: 771 (index) as follows: "*Dryophilum* Schw.= *Sclerotio* aff."

15. SPECIES REFERRED TO THE GENUS *DOTHIDEOVALSA* Speg.

*Eutypa Turnerae* seems to have been first described by Tassi, Bul. Lab. Ort. Bot. Siena 1899: 139, tab. X, fig. 1, 1899. A specimen growing on a species of *Turnera* from Panama received by Mr. D. P. Limber of the Bureau of Entomology and Plant Quarantine, agrees in every particular with Tassi's description and illustration. It resembles *Eutypa*, however, only in its sulcate ostioles and allantoid spores. The stroma is typically dothideoid.

Von Höhnelt, Frag. Myk. 695, 1911, reports that an examination of the type of *Epheliopsis Turnerae* P. Henn. Hedwigia 47: 270. 1908, shows that it is identical with Tassi's fungus, but was described by Hennings as a pycnidial form and thought to be related to *Ephelis*. Hennings apparently did not see the asci. Von Höhnelt says that Hennings' name should be discarded. He also suggests that Hennings' plant is probably the same as *Eutypella radulans* (Berk. & Curt.) Berl. An examination of a portion of the original material of this species in Michener's herbarium, as well as a comparison of Berlese's illustration of type material, Icon. Fung. 3: 75, pl. 92, fig. 2. 1905, shows that this is a true *Eutypella*, quite different from the Tassi and Henning's plant. A comparison of *Bagnisiella*, as treated by Theissen and Sydow, shows that Tassi's plant does not belong in that genus either.

Further study of specimens and literature shows that Ellis and Everhart gave this plant the herbarium name, *Bagnisiella eutypoides* Ellis & Ev. in herb. There is a specimen from Ellis so labelled in the Mycological Collections of the Bureau of Plant Industry, and it is listed in Seymour's Host Index, p. 518, 1929, as occurring on *Turnera ulmifolia*.

Further study shows that Hennings' and Tassi's fungus is very similar to that described by Lewis as *Bagnisiella Diantherae* on *Dianthera* from Texas, Mycologia 4: 70, pl. 58, 1912. A comparison of Lewis' material with that from Panama shows that both fungi are really Dothideaceous and congeneric.

Petrak, Ann. Myc. 32: 354-356. 1934, states that *Bagnisiella Diantherae* Lewis is a good *Eutypa* and calls it *E. Diantherae* (Lewis) Petr. He says he examined part of the original specimen of Lewis. His reason for excluding it from the Dothi-

deaceae is that it has allantoid spores, which never occur (sic) in the Dothideales. He says the specimen is too old to show perithecia (asci) which have apparently "verschleimt" and the conidia described probably do not belong to this fungus but are parasitic in the perithecia. He also adds that he does not know Spegazzini's *Dothideovalsa tucumanensis*, the type of the genus, but that according to Theissen and Sydow's description it is a typical *Eutypha* which should be called *E. tucumanensis* (Speg.) Petr. and therefore *Eutypha* is a synonym of *Dothideovalsa*.

*Dothideovalsa tucumanensis* Speg. Anal. Mus. Nac. Buenos Aires (Ser. 3<sup>a</sup>) 12: 414, 1909.

We have examined the type specimen of *Dothideovalsa tucumanensis* Speg. Spegazzini has the following note on the packet: "Ad caules *Chaetithylacis Tocantini* Tucuman 15/4/1906, stroma atro, coriaceo opaco, contentu parenchymatico vix distincto loculi 150 diam." The general appearance on the stems is like *Bagnisiella Diantherae* Lewis and *Eutypha Turnerae* Tassi, but the stromata are smaller as well as the locules. Spegazzini's type agrees in all essential characters with Tassi's and Lewis' species, differing chiefly in spore size. Spegazzini's species has spores  $4-6 \times 1 \mu$ ; Tassi's  $10-12 \times 2-3 \mu$  and Lewis'  $6-9 \times 1\frac{1}{2} \mu$ .

Lewis' species should therefore stand as *Dothideovalsa Diantherae* (Lewis) Theiss. & Sydow, and Tassi's fungus as *Dothideovalsa Turnerae* (Tassi) n. comb. *Epheliopsis* of Hennings, though a year older than *Dothideovalsa*, seems ineligible because it was described by the author as a genus of the Fungi Imperfecti. It might be argued, however, that as von Höhnelt has shown, it was really an ascogenous fungus, but seems that in view of Hennings' error *Dothideovalsa* should be adopted.

Spegazzini's type also shows that it is Dothideaceous and congeneric with Lewis' *B. Diantherae*. Theissen and Sydow, Ann. Myc. 13: 289-90. 1915, describe Spegazzini's species from this original specimen and find, as we have, that it has a typical loculate, dothideoid stroma and no paraphyses, though having sulcate ostioles and allantoid spores.

These species furnish a striking example of the fact that morphological characters usually regarded as confined to a certain

family or genus may occur in widely different families or orders. As a result of our studies we would refer all these species to *Dothideovalsa* with the following synonymy:

DOTHIDEOVALSA TUCUMANENSIS Speg. Anal. Mus. Nac. Buenos Aires (Ser. 3<sup>a</sup>) 12: 414. 1909.

**Dothideovalsa Turneræ** (Tassi) comb. nov.

*Eutypha Turneræ* Tassi Bul. Lab. Ort. Bot. Siena 1899: 139. 1899.

*Epheliopsis Turneræ* P. Henn. Hedwigia 47: 270. 1908.

*Bagnisiella eutypoides* Ellis & Ev. in herb.

DOTHIDEOVALSA DIANTHERÆ (Lewis) Theiss. & Sydow, Ann. Myc. 13: 290. 1915.

*Bagnisiella Diantheræ* Lewis Mycologia 4: 70. 1912.

*Eutypha Diantheræ* (Lewis) Petrak, Ann. Myc. 32: 354-6. 1934.

BUREAU OF PLANT INDUSTRY,  
WASHINGTON, D. C.

## NOTES ON THE MYCETOZOA—III

ROBERT HAGELSTEIN

Collecting activities were continued during the summer months of 1938 in the mountains of Pike and Wayne Counties, Pennsylvania, where we have operated for several seasons in the past. About a month in all was spent in several visits, at intervals, from the end of May to the end of July, and in company with either Joseph H. Rispaud or John D. Thomas. During our last excursion, after a week of heavy rain followed by three days of moist, humid weather, we found an extraordinary situation with nearly every decaying log or other suitable habitat covered with the fruiting bodies. On the day of our arrival 57 species were found, and during this and earlier trips many interesting forms were collected. Five of these are mentioned in the later notes.

The Foray of the Mycological Society of America was held in late August at the Forest Rangers School, at Duchesnay, Quebec. There, in the southern foothills of the Laurentian Mountains, surrounded by forest, lakes, and turbulent streams, we found an ideal locality. Furthermore, the occasion was a delightful and memorable one in the company of so many eminent American mycologists combined with the happy arrangements and entertainment provided by our Canadian hosts. Mr. Rispaud and I attended, and, following the Foray, spent another week in traveling and collecting across the Laurentides National Park as far as Lake St. John, about 150 miles north of the City of Quebec. The feature that stands out conspicuously in the results of the trip was the large number of rare species collected. Over 120 species and recognized varieties were found, and among them in addition to those described in the later notes are: *Comatriza aequalis* Peck, *Comatriza rubens* List., *Diachea subsessilis* Peck, *Fuligo muscorum* Alb. & Schw., *Hemitrichia abietina* (Wig.) List., *Margarita metallica* (Berk. & Br.) List., *Physarum bogoriense* Racib., *Physarum penetrale* Rex, *Physarum psittacinum* Ditm., *Physarum rubiginosum* Fries, *Trichia erecta* Rex, and

*Trichia subfusca* Rex. Many of these were found frequently in the limited time available, indicating that they were abundant over the large region; but in the mountains of the eastern United States we have found them only occasionally. The students in Quebec have an opportunity here not only to increase the knowledge about the geographical distribution of the Mycetozoa in North America, but to study the reasons for the abundance, whether due to timber or soil, or, if in some of the unglaciated areas of Quebec and Ontario the Mycetozoa have survived since pre-glacial time, and subsequently spread southward across the valley of the St. Lawrence River.

I am taking this opportunity to offer some suggestions to those who are conducting culture experiments in the germination of spores, and the raising of plasmodia and fruiting bodies of the Mycetozoa. The usual practice is to gather some fruitings in the field, sow the spores on various artificial media such as agar, gelatine, paper, etc., and feed the plasmodia with various powdered cereals; or sclerotium is used in place of the spores. This is usually done in small, restricted vessels. Such methods may be useful for certain purposes, but in the main are of little value beyond indicating the adaptability of the species to the forced habitat and food, and the possible changes in the fruiting bodies that may result. Unsatisfactory consequences must be expected when unnatural procedure is followed. There is no universal habitat nor a universal food for the Mycetozoa—no more than there is for any other group of living organisms—although the food supply in nature is closely related to the habitat. The student who wants results must provide a base for the plasmodium which will conform to what it has in its natural haunts.

Many species thrive on wood of various kinds; others on different leaves; others again require particular wood, leaves, or other material. This indicates that the character of the bacterial content is important in the development of certain species, as well as the absence of enemies, the acidity or alkalinity of the habitat, temperature, and perhaps other factors. The student should make a preliminary study of the conditions existing in nature, selecting a large, fertile, decaying log, and examining it at short intervals in different weather; noting its relation to the surround-

ings; the kind of wood it may be; the size in relation to the forms that may appear; the different species that are in harmony; the size of the developments of the fruiting bodies; and the intervals between repetitions of the same species. Specimens of each fruiting should be taken immediately after perfect maturity before natural germination of the spores has commenced, and before contamination with other spores. When ready to start experiments in the laboratory, a large portion of the original log should be taken, cultures made of the inherent bacteria and perhaps also the Protozoa, the wood broken into small pieces and thoroughly sterilized. This sterilized wood, with some attention paid to the former acidity or alkalinity, and impregnated again with food from the previously made cultures as may be found necessary, will form a natural habitat for the species originally inhabiting the log. Sufficient base should be used, about a half<sup>cu</sup> cubic foot for a plasmodium forming sporangial developments covering from six to eight square inches. The spores should not be scattered, but placed in masses so that the swarm-cells are in close proximity when germinated, thereby facilitating fusion to form the plasmodium. Experiments with clean washed sclerotium taken from the same log during the cold months, may also be conducted. Modifications should be worked out to fit particular conditions.

The mature fruiting bodies of the Mycetozoa are wet from the excess liquid discharged by the plasmodium during the process of fructification. The spores commence to germinate in this liquid immediately, and will continue to do so if moist conditions persist. Much of the material gathered in the field has spores that are partially germinated. The viability of the spores decreases with age, and rapidly in some species. Such spores take a longer time to germinate. This variation in the spores explains the lack of uniformity in the time of germination in different gatherings of the same species so often encountered. With satisfactory conditions, the plasmodium will vegetate for a definite period and until it reaches an appropriate size. The time and size varies with different species. If it should grow too large it may divide into two or more plasmodia and function as such. The fruiting bodies must have moist conditions while forming, and if these are interrupted by extreme drying, the development will be abortive.



Some species require but a few hours to reach complete maturity; others need several days, up to a week. The usual time is one or two days. With good, moist conditions, the cycle from the beginning of germination, through the vegetative stage of the plasmodium to the matured fruiting bodies, is about one month for most of the common species. With others it is much longer, up to five months. If dry weather intervenes during the period of the cycle, the spores will not germinate rapidly, or, the plasmodium through lessening of the food supply will draw itself deeper into the habitat, and become smaller and inactive. This will break the sequence of the cycles, but they are renewed each year as the first fruitings in the spring are usually from revived sclerotium. Plasmodium in the form of sclerotium may remain dormant in logs or other habitats for a long time, in fact for years, with no opportunity to revive and vegetate long enough to produce sporangia. Suddenly, with changed circumstances, fruiting bodies and sometimes those of rare species will appear on habitats which have been examined frequently and regarded as sterile. These conclusions are based on many field observations of the habits of the plasmodium extending over a long period of years. Taken in conjunction with moisture conditions in an area where the Mycetoza are known to be, it is possible to estimate with a fair degree of accuracy when the fruiting bodies may be expected in abundance. Moisture is not necessarily in the form of general rains. It will be in swamps, in the mists of enclosed lakes, in the spray of rushing water through small ravines or gorges, the dew, or a long condition of general humidity. We take all these into consideration when arranging the time for our excursions so that they are usually successful from a collecting point of view.

In the following notes the year 1938 is meant when no other year is given, and the collections were made by Mr. Rispaud and I, in company, unless otherwise indicated.

*ARCYRIA FERRUGINEA* Sauter. A fine development of the small phase discussed in my first series of Notes (*Mycologia* 29: 393-396. 1937) was found by Mr. Thomas in Pike County, Pennsylvania, in July. The fruiting appeared as several colonies about six feet from the ground on a dead, standing tree. In some colonies the sporangia are shortly cylindric; in others, ovoid or

subglobose. The spores are slightly smaller than in the earlier collections, many of them a trifle under  $10\ \mu$ . It was observed again that the sporangia require several days to arrive at complete maturity. N. Y. B. G. No. 4751.

*BADHAMIA OVISPORA* Racib. The species has come to me again from Canada, this time on manure in a greenhouse at Byron, Ontario, and collected by Mr. Eli Davis in April. N. Y. B. G. No. 8697.

*CALONEMA AUREUM* Morg. Collected on cow dung near Gainesville, Florida, in August, by Drs. William A. Murrill and Erdman West. The capillitium is sparingly branched and the spores are smaller than usual,  $11\text{--}12\ \mu$  diam. The species is not common and in habit and appearance resembles *Oligonema nitens* (Lib.) Rost., but distinguished in the field by the deeper, golden-yellow color. N. Y. B. G. No. 8883.

*COMATRICHA TENERRIMA* (Curt.) G. List. Two collections made in the Laurentian Mountains of Quebec, in August, consist of ovoid sporangia on long stalks. Aside from the long stalks, there is little to distinguish the form from *Comatricha pulchella* (Bab.) Rost. The capillitium and spores are a trifle paler, and the warts on the spores are not so prominent as in the latter species. N. Y. B. G. Nos. 4556, 4590.

*CRATERIUM LEUCOCEPHALUM* (Pers.) Ditm. A collection regarded as var. *rufum* G. List. was made at Willsboro, Essex County, New York, in September. The sporangia are sessile or shortly stalked and red or brownish-red all over including the well defined lids. A prominent pseudo-columella, in many instances, protrudes slightly through the lids, and the lime in this, as well as in the lime-knots, is also red occasionally. The sporangia are well developed, but the presence of plasmodiocarps indicates to me that the variety may be only an abnormal form or sport such as we find often in other species. The crystalline discs are not present in the walls or lime-knots, but this is not a constant feature as I have found in other phases of the species where they may be present at times. N. Y. B. G. No. 4746.

*CRIBRARIA ELEGANS* Berk. & Curt. The form is not often reported from east of the Mississippi. It was found by Dr. William

D. Gray, in Decatur County, Indiana, in August. N. Y. B. G. No. 8705.

*CRIBRARIA LAXA* Hagelstein. Two small fruitings were found at the type locality on Long Island, New York, in July. They are on leaves and identical with the earlier collections. The species has maintained its characters through seven collections made over a period of twelve years. N. Y. B. G. Nos. 1973, 1974.

*CRIBRARIA RUFA* (Roth) Rost. Sent here and collected by Mr. Eli Davis at Byron, Ontario, in September 1937. N. Y. B. G. No. 8485.

*DIACHEA THOMASII* Rex. Two large and finely matured colonies of this beautiful species were found in Pike County, Pennsylvania, in July, by Mr. John D. Thomas, one of my associates. They developed two days apart from plasmodia which were yellow shortly after emergence, and within a few feet of each other. Two full days were required to attain full maturity. The developments are typical with iridescent, coppery sporangia, partly on orange stalks as long as the diameter of the sporangia, or sessile and crowded. The spores appear olive-colored, are warted, and have the dark patches of smaller warts which are characteristic of the species. The spores measure 10–12  $\mu$  diam. The few records of the species are confined to North Carolina and Tennessee, more than five hundred miles from the present locality. It should be found again in the intervening territory. N. Y. B. G. No. 4745.

*DIDERMA OCHRACEUM* Hoffm. A specimen collected in the northern part of the Laurentian Mountains in Quebec, in August, and on the tips of moss, has wrinkled sporangia of an ochraceous color, 0.4–0.7 mm. diam. The outer wall is pitted with numerous small, irregular pits or depressions of a dark color which give a mottled appearance to the sporangia by reflected light. With transmitted light they appear to be thickenings in the closely attached yellow, membranous inner wall, pressed into the pits of the outer one, and orange-red in color. There are no lime granules in the walls nor a layer of lime granules between them. There is no columella. The profuse capillitium consists of slender, purplish-brown threads, pale at the tips, but not at the bases. The spores are lilac-brown, spinulose, 9–10  $\mu$  diam.

There are features about this form which if maintained in fur-

ther collections may be regarded as sufficient to separate it from *D. ochraceum*. For the present it is retained there. N. Y. B. G. No. 4593.

*DIDERMA SAUTERI* (Rost.) Macbr. This rarely collected species was found in the northern part of the Laurentian Mountains, Quebec, in August. The pale ochraceous, sessile sporangia encircle the tips of moss. The outer wall is dense with lime granules and separates readily from the membranous inner one, so that the sporangia appear wrinkled or shrunken. The columella is not defined, sometimes a mere thickening of the base, reddish or brownish, and giving attachment to the threads of the capillitium. The latter are scanty, colorless, straight and forking at the tips, with little branching. Although the development is normal and finely matured, the spores vary from 12–16  $\mu$  diam. They are moderately dark purplish-brown and spinose. N. Y. B. G. No. 4591.

*DIDYMIUM DIFFORME* (Pers.) Duby. A collection of var. *comatum* List. was found on leaves by Dr. C. L. Shear during the Foray of the Mycological Society at Duchesnay, Quebec, in August. The profuse capillitium consists of slender, straight, purplish-brown threads, of equal breadth throughout, and the spores measure 9–10  $\mu$  diam., smaller and paler than those of the typical form. N. Y. B. G. No. 4509.

*DIDYMIUM OCHROIDEUM* G. List. We have found this species heretofore only on Long Island, New York. It was found again on the stalks of skunk cabbage and moss at Sawmill Pond, Pike County, Pennsylvania, in June. There were several fruitings, probably, but as the species forms very small developments, and they are difficult to keep apart, they were joined as one specimen. The Pennsylvania material is typical. N. Y. B. G. No. 4754.

*LEPIDODERMA TIGRINUM* (Schrad.) Rost. Not often found in the East. A collection of typical sporangia was made in Pike County, Pennsylvania, in June, and would have made a fine specimen if we had seen it earlier. As it was, we were late and the sporangia are badly weathered. In order to get good material, one must be on the ground shortly after the fruiting bodies appear. A week's time is about the limit. N. Y. B. G. No. 4755.

*LICEA TENERA* Jahn. Two specimens developed in moist chambers have come here, one from Kansas, and the other from To-

ronto, the last on dung from Brazil. Both are very dark in color due to the presence of considerable refuse matter in the walls. The species is described as having little or no refuse matter but this is not always so. In that respect it is similar to *Licea flexuosa* Pers., although distinct in forming small, subglobose sporangia instead of the larger plasmodiocarps of the latter species. One of the specimens was referred to Prof. Jahn who confirmed the determination. N. Y. B. G. Nos. 8326, 8517.

LYCOGALA CONICUM Pers. The records for this species in North America are limited, so it is reported here that fine typical developments were found by Dr. William D. Gray, in Decatur County, Indiana, in August, and by Dr. Erdman West at Gainesville, Florida, in October. N. Y. B. G. Nos. 8719, 8882.

PERICHAENA CHRYSOSPERMA (Currey) List. On leaves, at Duchesnay, Quebec, in August, were found the small stalked forms formerly regarded by Lister as *Perichaena vermicularis* (Schw.) Rost. var. *pedata*, but transferred to the present species in the last edition of the Monograph. Each leaf carries one or two minute, brown, sporangia 0.15 mm. diam., on dark stalks of about the same height. The capillitium is fairly abundant with little branching, and is minutely spinulose. The spores measure 8.5–9.5  $\mu$  diam. N. Y. B. G. No. 4522.

PHYSARUM ALBESCENS Macbr. This unique form was collected by Dr. Erdman West at Gainesville, Florida, in November. It resembles *Leocarpus fragilis* (Dicks.) Rost., and differs therefrom mainly in the character of the outside wall which in the latter species is cartilaginous and shining without innate lime granules. The sporangia of the Florida specimen are sessile, with rough, outer walls composed of densely aggregated, yellow lime granules; the walls breaking away and separating from the membranous inner ones, which have white lime granules. The capillitium is typical with large, irregular, pale yellow lime-knots. The spores are purplish-brown, not dark, spinulose, and measure 10  $\mu$ . N. Y. B. G. No. 8885.

PHYSARUM CITRINELLUM Peck. This is one of the species that we have never observed in the field until this year, and it seems that all the collections from the eastern United States were made many years ago. It was abundant in the Laurentian Mountains of

Quebec in August, and six fruitings were found there. The sporangia are yellow, varying occasionally from white to orange, and on orange-red stalks. The habitat, as we found it, was among moss growing on the sides of wet rocks. There is no difficulty in recognizing the form with a hand lens. N. Y. B. G. Nos. 4441, 4446, 4486, 4493, 4565, 4706.

*PHYSARUM CITRINUM* Schum. A species akin to *Physarum globuliferum* (Bull.) Pers., and also to *Physarum murinum* List., but with bright, yellow lime in the wall, stalk, and lime-knots. It has been rarely reported from North America. A fine collection was made in Pike County, Pennsylvania, in June. N. Y. B. G. No. 4747.

*PHYSARUM CONGLOMERATUM* Rost. A poorly developed specimen collected in Quebec, in August, is regarded as closer to this species than to *Physarum contextum* Pers. because of the very pale and faintly marked spores. A few of these are  $10\ \mu$  diam., but the great majority measure 11–13  $\mu$ . It may be intermediate, or the large spore size may be due to imperfect development. Further collections are necessary to show clearly that the species is present in Quebec. N. Y. B. G. No. 4502.

*PHYSARUM CONTEXTUM* Pers. Var. *Mortoni* G. List. is merely a phase of this species in which the sporangia are more loosely clustered or free with a tendency to form short, imperfect stalks. Macbride regarded it as specifically distinct. Emphasis placed upon minor differences in other characters magnifies their importance, but they are found constantly in otherwise typical developments, when the species is found in abundance, and sometimes in the same fruiting. The form should not be regarded as a variety, much less as a species, and should be abandoned as superfluous and tending to cause confusion by its presence in the literature. Loosely clustered or free sporangia, with or without stalks, are often present in large developments of *P. contextum*, and occasionally an entire small colony may consist thereof. Two such selections have been made from the extensive Quebec material. N. Y. B. G. Nos. 4477, 4708.

*PHYSARUM LISTERI* Macbr. Described from Virginia in my Notes of last year. The only earlier North American record is from Colorado. The species appeared abundantly on leaves and

other ground matter under low vegetation on sand dunes along the shore of Lake St. John, Quebec, about a mile north of the village of St. Gedeon. Five fruitings were found in a few hours over a limited part of the area, but it was not collected elsewhere. The sporangia are about the same as those of the Virginia specimen but with practically no lime in the capillitium, reminding one of the near relation to the genus *Diderma*. N. Y. B. G. Nos. 4545, 4546, 4547, 4720, 4721.

*PHYSARUM ROSEUM* Berk. & Br. This rare species has come to me from Dr. Erdman West who has collected so many interesting forms in Florida. It was found at Gainesville in July 1935. In appearance it is similar to the common *Physarum pulcherrimum* Berk & Rav. but more reddish in color. The stalks are translucent and free from lime, and the lime-knots are large, angular and branching. In *P. pulcherrimum* the stalks are brittle, containing lime, and the lime-knots are small and rounded. These are the important differences between the species. N. Y. B. G. No. 8881.

*PHYSARUM SULPHUREUM* Alb. & Schw. During our visit to the Laurentian Mountains in Quebec, we made twelve collections of stalked and sessile sporangia of the species formerly regarded as *Physarum variabile* Rex. They all show the variations in shape of the sporangia, differences in shade of the yellow color, and irregularity of the lime-knots and stalks, that are usually found in developments of the form. The spores are purplish-brown, spinulose, and measure  $9.5-10.5\ \mu$  diam. Also, we made ten gatherings of sessile sporangia and plasmodiocarps, formerly known as var. *sessile* of *P. variabile*. In all characters except the manner of sporangial formation, these fruitings are identical, and the sessile sporangia in one series cannot be distinguished from similar sporangia in the other one.

Miss Lister, in the last edition of the British Monograph, regarded *P. variabile* as synonymous with *P. sulphureum*, and, at the same time, placed the var. *sessile* with *Physarum sessile* Brandza. The large amount of material from Quebec indicates clearly that *P. variabile* and *P. sulphureum* are the same species and all the collections are regarded here by the latter name which has priority. Also, it is certain that the plasmodiocarps and ses-

sile sporangia belong to the same species so that these are regarded as var. *sessile* of *P. sulphureum*.

The plasmodiocarps do not belong with *P. sessile* Brandza. That species as described and shown by specimens distributed by Brandza has white or grayish-white sporangia and plasmodiocarps with pale, almost smooth spores, which measure 7–8  $\mu$  diam. The spores of *P. sessile* are like those of *Physarum cinereum* (Batsch.) Pers., and it seems to be a robust phase of the latter. Brandza also proposed the name of *Physarum aureum* for yellow, sessile sporangia and plasmodiocarps with yellow lime-knots, and spores 10–12  $\mu$  diam. I have not seen an authentic specimen, nor have I seen anything from North America that can be definitely linked with the description. The description and figures, in some respects, are much like those of *Physarum Serpula* Morg. Brandza's name cannot be retained under the Rules of Nomenclature as *Physarum aureum* was applied by Persoon in 1794 to a form now regarded as synonymous with *Physarum viride* (Bull.) Pers.

*P. sulphureum* var. *sessile* has a striking resemblance to *P. Serpula*, particularly if small, selected specimens are compared. *P. sulphureum* forms single developments, varying in color and in the shape of the units of the fructification. *P. Serpula* forms many, small developments within a limited area, uniform in color and general shape, and the sessile sporangia are globose or subglobose, and never ovoid, piriform, or showing a tendency to a stalk. The plasmodiocarps of *P. Serpula* are narrower and longer, more sinuous, branched, net-like, or ring-shaped. The lime-knots are smaller and denser, with very short connecting threads which often present a *Badhamia*-like appearance. The spores are larger than in *P. sulphureum*, 10–12  $\mu$  diam., and in all specimens I have seen are paler on one side. Some of the Quebec collections of *P. sulphureum* also show a pale area on the spores, but this is not uniform throughout the collections.

*P. sulphureum* var. *sessile* is represented, under different names, by fig. *b*, on plate 22, in the second and third editions of the Lister Monograph. Figures *a*, on the same plate, are not the same form. I have here three specimens of the latter, one of which is probably from the same material figured by Lister. Their position is not clear. Further collections and field observations of the habit and



associations are required as they may be plasmodiocarps of another known species. Many specimens in the Herbarium of the New York Botanical Garden.

*PHYSARUM TESTACEUM* Sturgis. Fine and typical developments of this species were found by Mr. Eli Davis and Mr. W. D. Sutton at Komoko, Ontario, in October and November. The outer sporangium-wall is delicate, pliable, wrinkled or rugose, and with dense deposits of lime granules; the inner one, membranous, often widely separated from the outer one, but again firmly attached so that the two cannot be distinguished. The sporangia are sessile and measure 0.8–1 mm. across. The lime-knots are angular and branching. The spores are purplish-brown, spinulose, distinctly darker and more spinulose on one side, and measure 8.5–9.5  $\mu$  diam. The November collection shows the hollow columella mentioned by Lister.

In the past this form has been confused with *Physarum bitectum* List. and *Physarum didermoides* (Ach.) Rost. mainly on the relations of all three to a species described by Rostafinski as *Physarum Diderma*. The early literature is thereby somewhat muddled, but in the last edition of the British Monograph the three species are set out distinctly. That *P. testaceum* is the same as *P. Diderma* Rost. is extremely doubtful. The Polish text of Rostafinski has been translated with differing interpretations; the type specimen is not available; and, besides, *P. testaceum* seems to occur only in North America and the first recorded collections—unless Rostafinski had it—were not made until many years after the Polish Monograph was published. It is better to accept the name given by Sturgis. N. Y. B. G. Nos. 8789, 8828.

*STEMONITIS UVIFERA* Macbr. The principal character of this form is that the spores are clustered in groups; otherwise it is similar to *Stemonitis splendens* Rost. In the collection of Mycetozoa acquired in 1938 by the New York Botanical Garden from Dr. William C. Sturgis, there were found two specimens obtained by Dr. Sturgis from the late A. P. Morgan of Ohio. One was collected in June 1895, and the other in August 1896, many years before the form was found again and proposed as a species. There is nothing to indicate where the collections were made. Nearly all the spores in the earlier collection are free and measure 7–9  $\mu$

diam. There are a few small, loose clusters. In the later collection, all the spores are firmly clustered in small groups, and the spores measure  $8.5\text{--}11\ \mu$  diam. Otherwise there is nothing important enough to distinguish the sporangia from those of *S. splendens*.

The form has not been found often and seems to vary in the degree of clustering and the spore size. It is probably no more than a sport or abnormal phase of *S. splendens*. N. Y. B. G. Nos. 10471, 10520.

TRICHAMPHORA PEZIZOIDEA Jungh. A species remarkable for the extreme variations in the capillitium, and in the size, color, and marking of the spores. The constant features are the broad, saucer-shaped sporangia on translucent, reddish-brown stalks. A fine collection was made by Dr. Erdman West at Gainesville, Florida, in July. The slender threads of the capillitium vary in different sporangia, sometimes filled with lime throughout like a *Badhamia*, or with less lime like a *Physarum*. The spores are dark purplish-brown, strongly spinose with long spines, and measure about  $12\ \mu$  diam. N. Y. B. G. No. 8884.

THE NEW YORK BOTANICAL GARDEN

## PHOTOGRAPHS AND DESCRIPTIONS OF CUP-FUNGI—XXXII. PODOPHACIDIUM

FRED J. SEAVER

(WITH 1 FIGURE)

In 1868 Niessl founded the above named monotypic genus. Because of the peculiar method of dehiscence of the apothecium Saccardo placed the type species in the genus *Urnula*, calling it *Urnula terrestris*.

In 1907 Boudier established the genus *Melachroia* based on *Peziza xanthomela* Pers. At the same time he transferred to his new genus *Podophacidium terrestre* Niessl. Why he did not use the generic name proposed by Niessl instead of proposing a new one is not apparent. Since that time various authors have claimed that *Podophacidium terrestre* was identical with *Peziza xanthomela* Pers. For the most part, however, the two species have been kept distinct and placed in different genera.

During the Mycological Foray at Quebec in the summer of 1938, the writer encountered for the first time in the field a fungus which he identified as *Podophacidium terrestre*. This fungus, however, agreed in every detail with the description and illustration of *Melachroia xanthomela* Boudier. Examination of our herbarium disclosed that the species had been seldom collected in America, and never under the name assigned to it by Boudier.

The earliest collection contained in our herbarium was one obtained by B. O. Dodge in Wisconsin in 1909. This was identified by Dr. H. Rehm of Germany as *Urnula terrestris*, while our specimen collected in Quebec was readily referred to *Melachroia xanthomela* Boudier. A fragment of the material collected at Wisconsin was revived and found to agree in every detail with the recent collections in Quebec. This field observation has convinced the writer that the two species *Podophacidium terrestre* Niessl and *Melachroia xanthomela* Boudier are one and the same thing. If this fungus is to be maintained in a separate genus

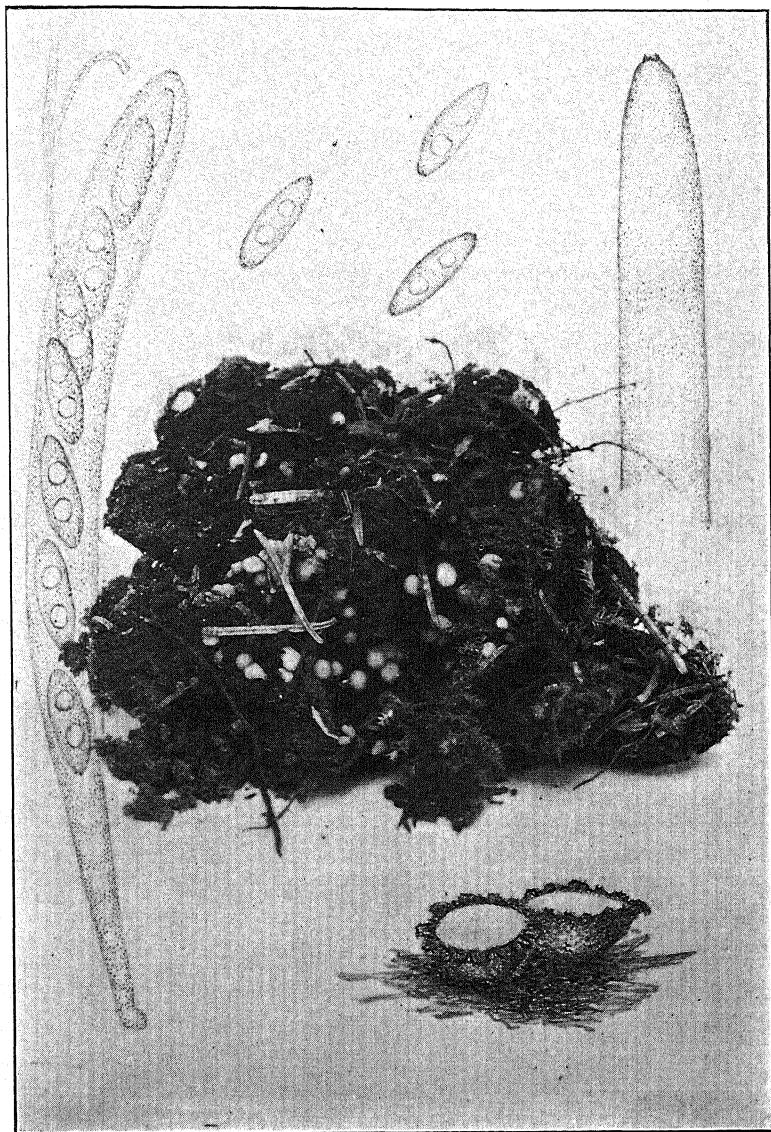


FIG. 1. *Podophacidium xanthomelum* (Pers.).

the name *Podophacidium*, proposed by Niessl in 1868, would have priority over *Melachroia* established by Boudier in 1907.

Up to this time there were just four specimens of this species in the herbarium of The New York Botanical Garden from North America: the one already referred to, collected by B. O. Dodge in Algoma, Wisconsin, in 1909; one collected by H. S. Jackson in Toronto, Canada, in 1932, and determined by the writer; one collected in January 1935 by Raymond H. Torrey, and identified by Miss Ellys Butler, and a fourth collected in Quebec in 1935 by Dr. F. L. Drayton, and communicated by Lawrence White to the writer for determination. This species is therefore sufficiently rare to deserve honorable mention.

Two collections were made in Duchesnay, Quebec, during the summer of 1938, one by H. H. Whetzel and the other by the writer. The diagnosis is as follows:

*PODOPHACIDIUM* Niessl in Rab. Fungi Eu. 1153. 1868.

*Melachroia* Boud. Hist. Class. Discom. 96. 1907.

Apothecia contracted at the base, substipitate, obconic to turbinate, opening with a lacinate aperture; hymenium freely exposed at maturity and bright colored; asci clavate, inoperculate, 8-spored; spores simple, hyaline.

TYPE SPECIES, *Podophacidium terrestre* Niessl.

***Podophacidium xanthomelum*** (Pers.) Kavina, Crypt. Czech. Exsicc. 217. 1936.

*Peziza xanthomela* Pers. Syn. Fung. 665. 1801.

*Peziza xanthomela* Pers. Myc. Eu. 1: 296. 1822.

*Podophacidium terrestre* Niessl in Rab. Fungi Eu. 1153. 1868.

*Aleuria xanthomela* Gill. Fr. Champ. Discom. 207. 1886.

*Humaria xanthomela* Sacc. Syll. Fung. 8: 128. 1889.

*Urmla terrestris* Sacc. Syll. Fung. 8: 550. 1889.

*Melachroia xanthomela* Boud. Hist. Class. Discom. Eu. 97. 1907.

*Melachroia terrestris* Boud. Hist. Class. Discom. Eu. 97. 1907.

Apothecia thickly gregarious, occasionally a few closely crowded, the hymenium bright yellow with a slightly olive tint, surrounded with a dark brownish or almost black lacinate border, the outside

of the apothecium dark brownish or nearly black reaching a diameter of 3–4 mm.; asci clavate reaching a length of 90–125  $\mu$  and a diameter of 7–9  $\mu$ ; spores ellipsoid, the ends slightly attenuated, usually with two oil drops 5–6  $\times$  10–17  $\mu$ ; paraphyses very slender, branched.

On soil in coniferous woods.

TYPE LOCALITY: Europe.

DISTRIBUTION: Washington to northern New York, Toronto and Quebec; also in Europe.

ILLUSTRATIONS: Rab. Fungi Eu. 1153; Niessl Beit. *pl.* 7, *f.* 50; Boud. Ic. Myc. *pl.* 449 (as *Melachroia xanthomela* (Pers.) Boud.); Cooke, Mycogr. *pl.* 11, *f.* 41 (as *Peziza xanthomela* Pers.), Papers Mich. Acad. Sci. 22: *pl.* 15, *f.* 2.

THE NEW YORK BOTANICAL GARDEN

## KARSTEN'S TYPE SPECIMENS OF HYSTERIACEAE ON CONIFERS

M. L. LOHMAN

(WITH 4 FIGURES)

Certain specimens collected by Karsten have been examined with attention to associated conidial stages as well as features which he described.<sup>1</sup> One, *Hysterium sphaeriodes* Karst., a species which has been collected but once in the United States (White Mountains; on wood of *Betula*), is discussed in a previous paper (15). Of those with a coniferous substratum several are of particular interest for their occurrence in North America or for their conidial status (*Gloniella ambigua*, now referred to *Hysterium*; *Lophium laeviusculum* and *L. mytilinum*, both of the genus *Mytilidion*).

Karsten treats the Hysteriaceae in three of his general works (6, 7, 9), admirably combining in his descriptions, as Hintikka states (5), detail of diagnostic features with clarity and brevity in exposition. The descriptions of new species in the first are republished by Rabenhorst (16). In general his species for Finland and Lapland have not been reported elsewhere in Europe, or the names as synonyms have received varied or inconsistent treatment. Only recently has American material been so identified, and then usually with some question. As to *Mytilidion Karstenii* Sacc. (*Lophium mytilinum*), which is not uncommon on pine wood and bark in New England, it is interesting to note that in the early American compilations Cooke (2) reports no collections suggestive of the species, but Ellis (3) possibly refers some to *M. fusisporum* (Cooke) Sacc.

### GLONIELLA AMBIGUA Karst. (FIGS. 1, 2A)

A specimen marked "Mustiala in ligno vetusto pineo. 2 Nov. 1890," with descriptive notes and other data as published by

<sup>1</sup> For the opportunity to study this material the writer is very grateful to Professor Harald Lindberg, of the University of Helsingfors.

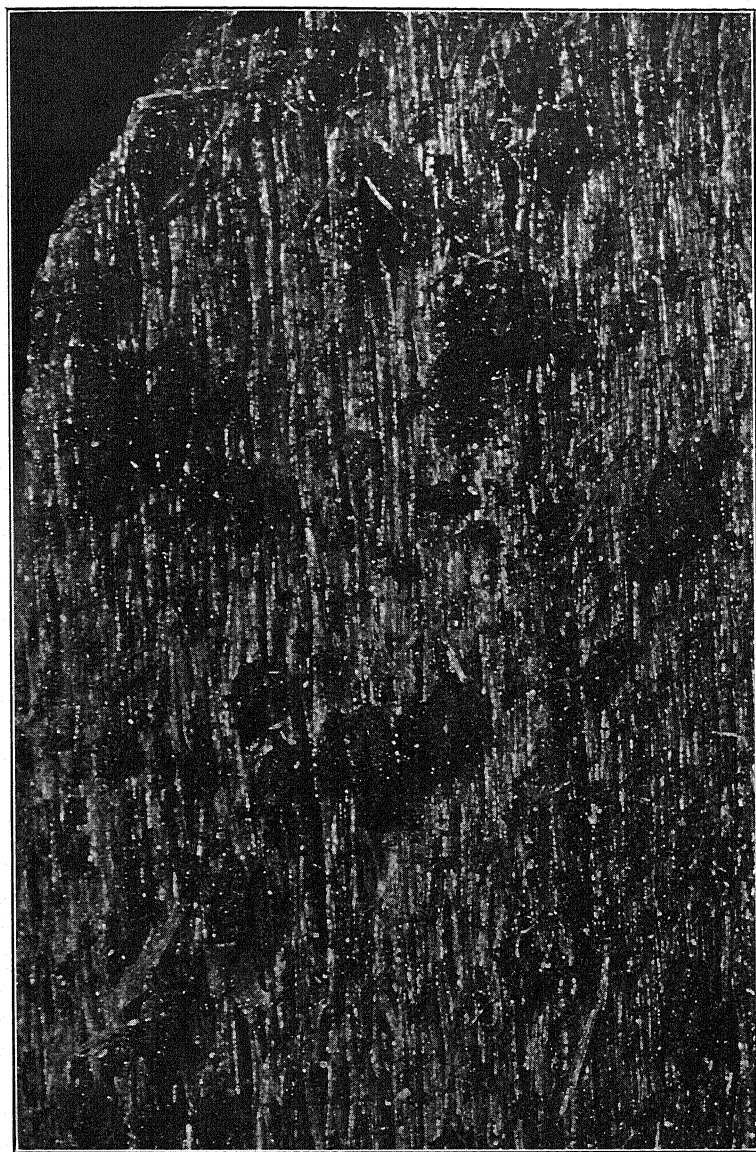


FIG. 1. *Gloniella ambigua* Karst., showing the *Sporidesmium* stage;  $\times 30$  ("Mustiala in ligno . . . pineo . . . 1890").



Karsten (10), is the type for *Gloniella ambigua*. The wood is coniferous, and hysterothecia and conidia (*Sporidesmium*) are abundant. The hysterothecial walls are only subcarbonaceous; mature spores are brown rather than hyaline, and considerably shorter than described. The conidial stage is not identifiable with any form species recorded for coniferous wood in northern Europe.

Mature hysterothecia are scattered, up to 0.5 mm. long, nearly superficial, with prominent longitudinal fissure and complete basal wall. However, many are immature and only erumpent, with the sunken ends acute. Asci measure  $70-80 \times 10-12$ ; ascospores  $21-24$  ( $26$ )  $\times 6$ .<sup>2</sup> The spores are biseriate-overlapping to subtriseriate, constricted at the septa and yellowish to clear brown when finally 3-septate. Conidia, which blacken the wood, occur singly or closely aggregated in definite, linear, minute sori, and measure  $15-22$  in diameter, when irregularly globose, or  $25-30 \times 12-15$ , when oblong. Pycnidia are lacking. None of the fructifications examined had ascospores as long as Karsten noted, i.e., 27-34.

The species is an interesting one for its apparent relationship with *Hysterium hyalinum* C. & P. The two have similar conidial stages, and broadly fusoid ascospores which darken slowly (14). It appears to be distinct when compared with reasonably well known species of *Hysterium* in Europe and North America. The name, ***Hysterium Karstenii*** nom. nov., is proposed for the species, since *Hysterium ambiguum* is preoccupied.

HYSTERIUM CONIGENUM Karst. and H. STROBILARIUM Karst.

(FIG. 2B)

The fungus on cone scales of *Picea* to which Karsten (8) formally applied first the name *Hysterium strobilarium*, and later (9), *Glonium strobilarium*, might well be retained under *Glonium*.

Two specimens have been examined—of different collection date, but identical: (1) Karsten's Fung. Fenn. 467 under the name *Hysterium conigenum* Moug. ("Merimasku, April"), in the Farlow Herbarium, and a portion of the same from the Karsten Herbarium; (2) Specimen in the Karsten Herbarium labelled "*Hysterium conigenum* Karst. (non Moug. et Nestl.) . . . *Hysterium*

<sup>2</sup> All measurements of microscopic features are given in  $\mu$ .

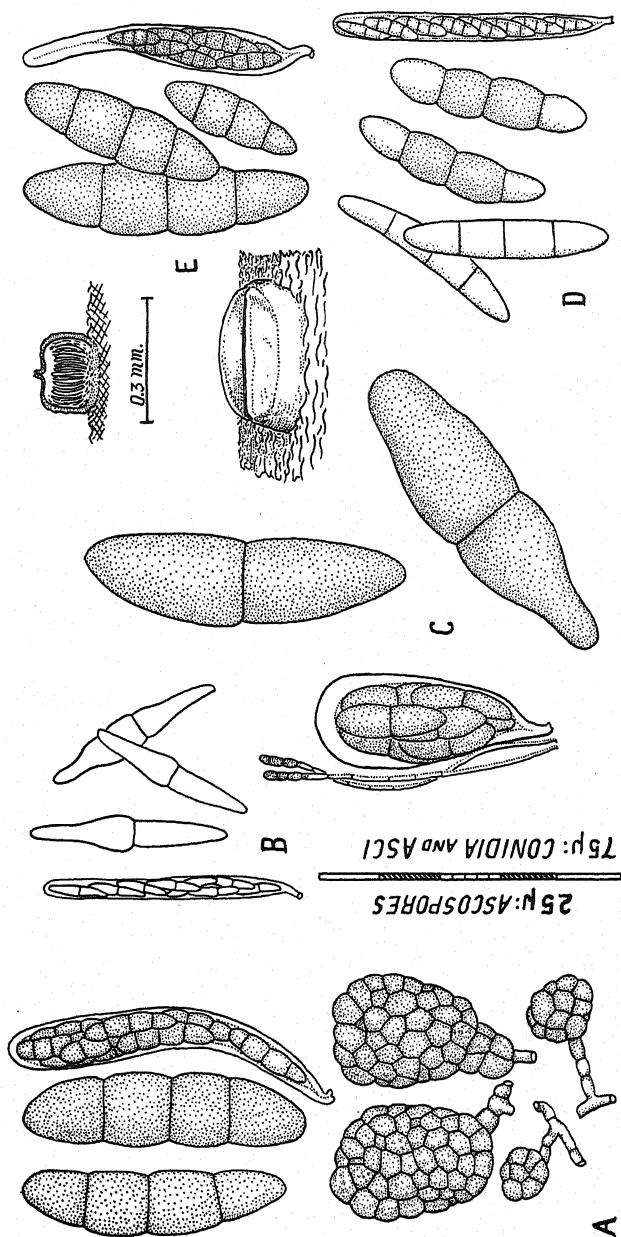


FIG. 2. A, *Gloniella ambigua* Karst.; B, *Glonium strobilarium* Karst. (*Hysterium conigenum* Karst. "Mustiala . . . 1867"); C, *Hysterium conjugens* Karst. Fung. Fem. No. 858; D, *Hysterium curtum* Karst. ("Soukelo ad arbor. frond . . . 1861"); E, *Mytilidion decipiens* (Karst.) Sacc. ("Lophium decipiens Karst. . . Tammela . . . 1869").

*strobilarium* Karst. . . . Mustiala, in strobilis abietis, 5 Junii 1867, leg. P. A. Karsten." Karsten cites both (6) under *Hysterographium conigenum* (Moug. et Nestl.). The specimens agree with his descriptions, particularly the second and more complete one (7, p. 235), wherein he cites neither of them but instead, Mougeot and Nestler's Stirp. Crypt. 75, which authors refer to *Hypoderma*.

The hysterothecia are closely aggregated, black, punctiform but elliptic-oblong, erumpent by elongate crests, 0.15 to 0.2 mm. in length, subcarbonaceous and parenchymatic. Asci are 55–60  $\times$  6, straight cylindric and paraphysate; ascospores 14–16  $\times$  2.5–3, obliquely uniseriate, fusoid with the upper cell swollen at the septum, slightly curved, greenish-hyaline and noticeably constricted.

Considering *Hysterium strobilarium* Karst. a synonym of *Dichaena strobilina* Fries is no less confusing because of the frequently recorded uncertainty of the latter.

HYSTERIUM CONJUNGENS Karst. AND HYSTEROGRAPHIUM  
CONJUNGENS Karst. (FIG 2C)

Karsten (7, 9) refers materials described (6) as *Hysterographium conjungens* to *Glonium graphicum* (Fries) Duby. However, these specimens do not conform to the usual conception of *G. graphicum* in Europe.

The specimen here considered the type is labelled "Mla. ad cortic. Pini sylv. P. A. Karsten. 13 Apr. 1868." His descriptions—in 1871, and on distribution No. 858—are based upon the notes on this packet. But the printed label on his distribution reads "Mustiala . . . Maj."

The four fructifications in the type specimen are superficial, black, widely scattered and without a subiculum, up to 1 mm. in length, elongate but with the hymenium exposed. The exciple is leathery rather than carbonaceous. In view of Karsten's data on the packet and scarcity of material preparations were made instead from his No. 858 in the Farlow Herbarium in which there are a number of scattered apothecia similar to those described above. Asci are pyriform, 50–60  $\times$  18–20, with numerous septate, simple (or branched?) paraphyses with swollen, dark tips. Karsten (6)

describes the asci as being oblong, giving no measurements, but on the packet records them as  $60-70 \times 21-25$ . In shape and size, thick wall, and conglobate arrangement of spores, they differ from *G. graphicum* (Fries) Duby as the species is commonly recognized. The ascospores are elliptic-oblong to broadly fusoid, 2-celled, clear brown when mature and measure  $22-28 \times 8-10$ . Since Karsten recorded them as  $28-38 \times 9-12$ , considerable variation in length is indicated.

This fungus may be a species of the Patellariaceae.

#### HYSTERIUM CURTUM Karst. (FIG. 2D)

Karsten (9), in following Saccardo, considers *Hysterium curtum* (7) under *Gloniella*. Although he records the species for several localities on wood of conifers and hardwoods, it is seldom reported in European literature and its exact status remains questionable.

A specimen labelled "Soukelo ad arbor. frond. Karsten 21 Juni 1861" appears to be the type. Ascospores are sketched as being 3-septate, unstricted, curved and hyaline, with pointed ends—apparently immature. They are noted as " $13-16 \times 2\frac{1}{2}-3\frac{1}{2}$ ." The several fructifications examined yielded in each case empty asci together with 8-spored immature asci,  $60-80 \times 6$ , with greenish-hyaline, elliptic-oblong, 1- to 3-septate spores arranged obliquely in a single row. Free spores on the wood and about the fructifications were found in abundance. They are fusoid-oblong,  $12-16 \times 3-4$ , 3-septate, deeply constricted, with central cells dark-brown and end cells yellowish.

With the fructifications nearly spherical, up to 0.4 mm. long, the species may be a *Lophiostoma*.<sup>3</sup>

#### LOPHIUM DECIPIENS Karst. (FIGS. 2E, 4A)

Karsten's specimen (labelled "Runsala, enbark, 2 Juni, 1861") distributed as Fung. Fenn. No. 767, in the Farlow Herbarium, con-

<sup>3</sup> In general, the specimen examined conforms to Karsten's description. However, since the spore measurements on the packet are not strictly identical with those published, it is possible that his description is based on several specimens, or on another, either from the Kola Peninsula, or from the vicinity of Turku.

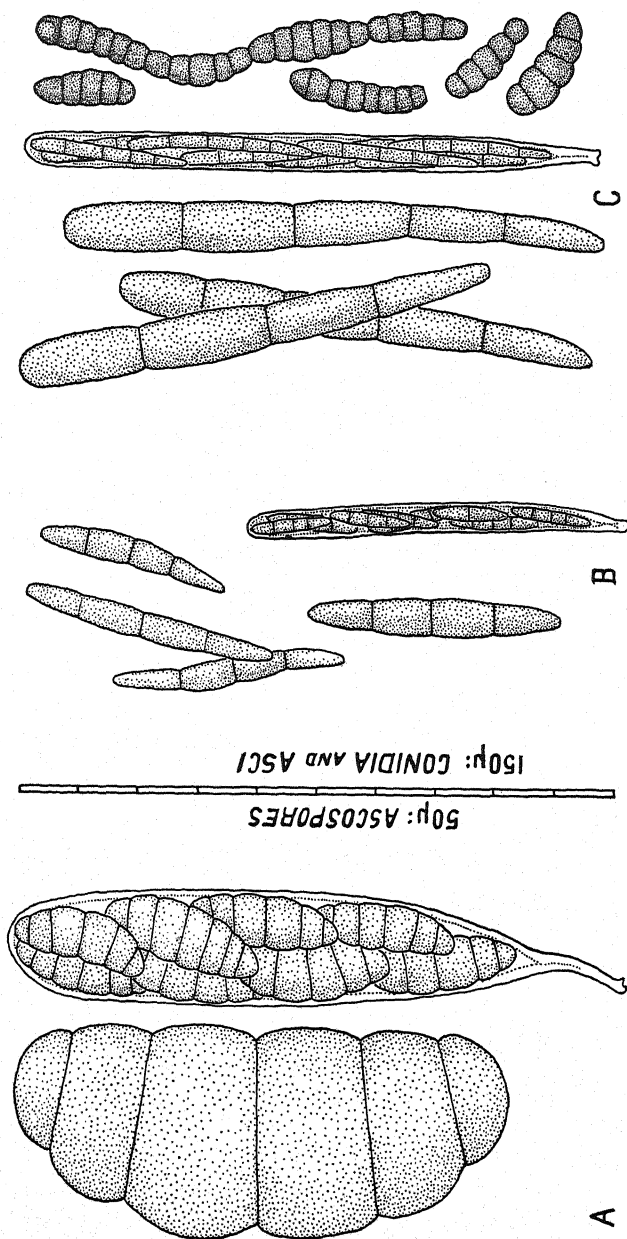


FIG. 3. *A*, *Hysterium dissimile* Karst. ("Ruva"); *B*, *Mytilidion laeviusculum* (Karst.) Sacc. (*Lophium laeviusculum* Karst. Sipilä . . . 1866"); *C*, *Mytilidion Karstenii* Sacc. and associated *Septonema*—"Vaasa . . . 1870".

forms to his descriptions (6, 7) of *Lophium decipiens*. His specimen labelled "Tammela . . . in cort. Juniperi, 1. 29 Maji, 1869," is identical. In these hysterothecia are oblong or nearly circular, 0.25–0.3 (0.4) mm. long, flattened to slightly sunken above, with narrow crests and fragile, prosenchymatous walls. Asci are 65–80  $\times$  7–8; enlarged toward the base. Ascospores are yellow-brown, 3-septate, (12) 15–18 (20)  $\times$  4–6, slightly constricted at the septa, fusoid but variable in shape, often a single ascus with both elongate and oblong individuals.

The species has been reported as occurring in Europe on cones of *Larix* and *Pinus*, on bark of *Pinus*, and on bark and leaves of *Juniperus*, but probably more than one species is represented by these records. Report of the fungus on bark of *Picea* in Michigan, by the writer (13), is incorrect.

*Mytilidion decipiens* (Karst.) Sacc. stands as a small-spored species inhabiting bark (and leaves?) of *Juniperus*, and possibly other conifers, with depressed-conchiform, nearly circular hysterothecia, and obclavate asci. It is similar to two needle-inhabiting species, *M. californicum* Ellis & Hark., and *M. aciculum* Wint. which has larger asci and spores, and to *M. tortile* (Schw.) Sacc., although with this species the relationship is less evident because of its vertically appressed fructifications and narrow cylindric asci (cfr. Rehm (17), and Bisby (1, p. 322, 328)).

#### HYSTERIUM DISSIMILE Karst. (FIG. 3A)

*Hysterium dissimile* Karst. appears to be a species of the Patellariaceae.

The specimen examined is labelled "Ruva." which, together with the descriptive notes on the packet, agrees with his description (7). Ascospores were found to conform closely, but asci measured larger. Giant stylospores not mentioned by Karsten were also observed.

The apothecia are black, 1–1.6 mm. in diameter, fleshy-leathery and superficial, elongate at first but circular or irregular at maturity. Hymenium and tips of asci do not blue with iodine; paraphyses are abundant, granular, simple (?), agglutinated and brown at the tips. The hypothecium is thick. Asci are thick-walled, clavate, 150–165  $\times$  22–30, with conspicuous stalks. Ascospores and

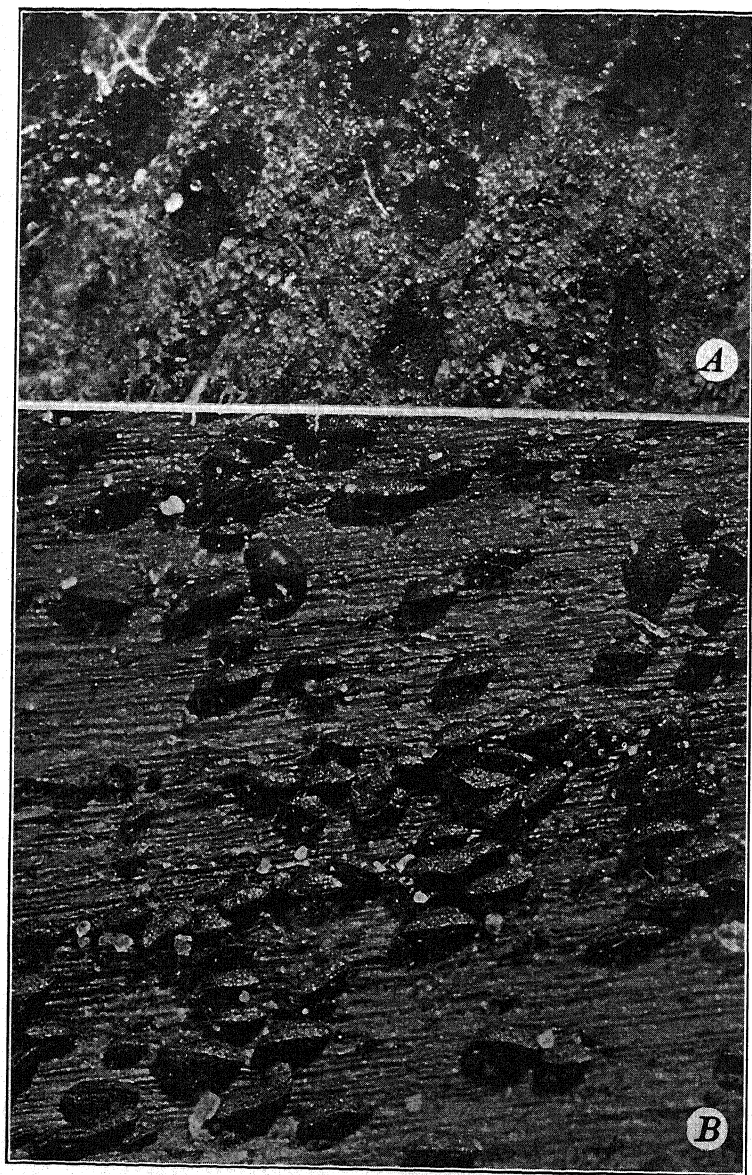


FIG. 4. A, *Mytilidion decipiens* (Karst.) Sacc. on bark of *Juniperus*;  $\times 30$  (Specimen the same as in fig. 2E); B, *Mytilidion laeviusculum* (Karst.) Sacc. on wood of *Pinus*;  $\times 30$  (Specimen the same as in fig. 3B).

stylospores are yellow-brown, elliptic, slightly curved, constricted at the septa, with rounded ends,  $36-45 \times 12-15$ , when 5- to 6-septate, and  $45-52 \times 12-16$ , when 8-septate.

In his description Karsten questions the generic position of the species; in his revision (9), he omits it without explanation.

LOPHIUM LAEVIUSCULUM Karst. (FIGS. 3B, 4B; and (15)  
Plate II, B)

Karsten's *Lophium laeviusculum* is a well-founded species now known as *Mytilidion laeviusculum* (Karst.) Sacc. It remains little known in Europe and has been recorded but once (13) for the United States, when collected on wood of *Larix* in Michigan.

A specimen labelled "Sipilä ad lign. fabrefact . . . pineum, 22 Maj 1866" appears to be that upon which Karsten based his distribution, Fung. Fenn. No. 771, and may be considered the type. The fructifications, which have thin, prosenchymatous walls, are conchiform, superficial, but often seated in fissures of the wood, up 0.45 (0.5) mm. in length and 0.75 mm. in width. Asci measure  $55-65 \times 6-7$ , and the spores  $16-21 \times 2.5-3$ . No. 771 in the Farrow Herbarium is without spores.

The minute vertically appressed fructifications and small narrow-fusoid, unstricted, yellow-brown spores of the species delimit it clearly. Its intermediate position with respect to *Bulliardella* and *Mytilidion* has been discussed (11, 15).

LOPHIUM MYTILINUM (Pers.) Fries, sense of Karsten, and  
LOPHIUM MYTILINUM Karst. (FIG. 3C)

Karsten's publications (6, 7, 9) indicate the common occurrence of the fungus now known as *Mytilidion Karstenii* Sacc., on bark, wood and needles of *Pinus* throughout Finland, especially northward in Lapland in the region of Kola. The species is well defined in the literature, but with respect to the principle of type specimens it presents some difficulty.

In a specimen labelled "*Mytilidion Karstenii* Sacc. Vaasa, Julio, 1870. P. A. Karsten," the hysterothecia are superficial, swollen-conchiform, striate,  $0.5 \times 0.4$  mm., and as high as broad. Asci are narrow cylindric,  $135-150 \times 8-9$ ; ascospores  $37-45 \times 3.5-4$ ,



occasionally 3- but mostly 4-septate (yet Karsten records 8-celled spores), slightly tapered toward the lower end which is often slightly curved, slightly and equally constricted at the septa, and clear yellow brown. This material is more typical of his description than is his Fung. Fenn. No. 93 in which ascospores measure  $31-37 \times 3.5-4$ , and are prominently constricted at the central septum. In the apparent absence of a specimen in the herbarium of Saccardo (Gola, 4) and because Karsten does not mention a definite collection in his revision (9), it is proposed that this specimen be considered the type. The hysterothecia resemble those of *M. parvulum* Lohman; the ascospores, *M. rhenanum* Fuckel and *M. scolecosporum* Lohman, but are intermediate between these two in length.

A *Septonema*, with conidial chains rather fragmented, is associated in the specimen. This may be considered to be genetically connected, in view of a similar connection that is demonstrated culturally (12) for *M. scolecosporum* from Wisconsin. Conidia observed in specimens of *M. Karstenii* Sacc. collected in New England are fuscous, 3- to 5-septate with noticeable constrictions, and measure  $18-30 \times 6-7$ . In the Karsten specimen similar conidia when 3-, 4- or 5-septate measure, respectively,  $18 \times 6$ ,  $24 \times 7.5-8$ , and  $30 \times 7-8$ . This stage cannot be identified with any form species already recorded on *Pinus* in northern Europe.

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## EXPLANATION OF TEXT FIGURES

FIG. 1, *Gloniella ambigua* Karst., showing the *Sporidesmium* stage;  $\times 30$  ("Mustiala in ligno . . . pineo . . . 1890"); 2, A, *Gloniella ambigua* Karst.; B, *Glonium strobilarium* Karst. (*Hysterium conigenum* Karst. "Mustiala . . . 1867"); C, *Hysterium conjungens* Karst. *Fung. Fenn.* No. 858; D, *Hysterium curtum* Karst. ("Soukelo ad arbor. frond . . . 1861"); E, *Mytilidion decipiens* (Karst.) Sacc. ("*Lophium decipiens* Karst . . . Tammela . . . 1869"); 3, A, *Hysterium dissimile* Karst. ("Ruva"); B, *Mytilidion laeviusculum* (Karst.) Sacc. ("*Lophium laeviusculum* Karst. Sipilä . . . 1866"); C, *Mytilidion Karstenii* Sacc. and associated *Septonema* — ("Vaasa . . . 1870"); 4, A, *Mytilidion decipiens* (Karst.) Sacc. on bark of *Juniperus*;  $\times 30$  (Specimen the same as in fig. 2E); B, *Mytilidion laeviusculum* (Karst.) Sacc. on wood of *Pinus*;  $\times 30$  (Specimen the same as in fig. 3B).

## NOTES AND BRIEF ARTICLES

### FUNGI OF INDIA

Supplement No. 1 to the above named work by Butler and Bisby has recently been published as Scientific Monograph No. 12 by the Imperial Council of Agricultural Research. The supplement is by B. B. Mundkur. New records in this work increase the total number of fungi and slime moulds from 2351 to 2868 species. One new species and six new combinations are recorded.  
—F. J. SEAVER.

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### THE FUNGI OF MANITOBA AND SASKATCHEWAN

The above work has just been published by the National Research Council of Canada. The volume, consisting of 189 pages and thirteen plates, is neatly bound in cloth. It contains records of nearly 2,800 species of the fungi of those Canadian provinces, including more than thirty which are new to science, and is the work of G. R. Bisby, A. H. R. Buller, John Dearness, W. P. Fraser, R. C. Russell, and H. T. Güssow. No other credentials are necessary. In making determinations the authors have been assisted by specialists in various parts of the world. The work contains an extensive bibliography and host index. It is a decided contribution to the mycoflora of Canada.—FRED J. SEAVER.

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### THE GENUS *MYCENA*

The recent publication by Dr. Robert Kühner of Lyon, France, on the genus *Mycena* is particularly worthy of the attention of American mycologists. Dr. Kühner has not only completed a comprehensive survey of the genus from a taxonomic standpoint, but has included detailed accounts of his methods of study, the development of the fruiting body in this genus, the anatomical characters of the species and also their nuclear history in many

cases. As a result, the work is a remarkably complete biological study of the genus. It furnishes American investigators with an account of the European species based on a critical study of specimens rather than a compilation of the literature as has too often been the case in previous surveys. Kühner has wisely adapted a rather broad concept of the genus, including in it many species previously referred to such related genera as *Collybia* and *Omphalia*. This enhances the usefulness of the work immensely, but will raise certain objections, as for instance, placing *Collybia myriadophylla* in *Mycena*. Some will also disagree with Dr. Kühner on certain nomenclatorial principles, even though they admit, at the same time, that he has good reasons for his beliefs.

Since accounts of American species are also included, and placed in their positions in the structure of his classification, the work will be eminently useful as a field manual for American students.—  
ALEXANDER H. SMITH.

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#### URNULA GEASTER

In a recent article on the above named species (*Mycologia* 29: 60–65. 3 fig. 1937) the writer referred to the fact that this species, described by Peck in 1893, had been frequently collected in Texas, but so far as known had not been found outside of that State. It was further stated that there seemed to be no reason why it should not occur over a wider range.

In the light of these facts it is interesting to note that in a recent article by Rokuya Imazeki (*Jour. Japanese Botany* 14: 680–684. 1938) it is claimed that this species, previously known from a very restricted area in America, has now been found in Japan. The photographs and drawings indicate clearly that it is the same species. While the writer cannot read the discussion in Japanese, the summary of the article in English is as follows: “It is a matter of great interest that *Urnula Geaster* Peck was collected in Japan, last autumn. The collector is Mr. H. Yoshii, Assistant Professor in Kyusyu Imperial University. He got only a single apothecium which was still immature and closed. This material agrees with the description given by Dr. Seaver, except the form of paraphyses, which are slender filiform as noted by Heald and Wolf. The

writer believe that this is due to the apothecium being immature."

This is only another illustration of the unusual and unpredictable distribution of many of the species of the fungi. It would be difficult indeed to account for it, and we merely accept the facts as they are.—FRED J. SEAVER.

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#### THE GENUS SEPTOBASIDIUM<sup>1</sup>

A volume under this title by Dr. John N. Couch, Professor of Botany at the University of North Carolina, has recently appeared. This work was started more than ten years ago, and at that time this fungus genus was represented by about 75 species, while the present volume contains descriptions of 176 species, many of which have been described as new by the author of the work. The entire volume comprises 480 pages, 114 plates and 60 text figures.

The introduction presents a description of the life histories of some of the typical species of this genus and the account reads like a fairy story. The interesting and intimate correlation of the fungus with its insect host is almost unbelievable. All of the species of this genus are parasitic on scale insects, which in turn suck their nourishment from the plant host on which they live. The fungus appears not to be able to live without the insect on which to feed. The insect, on the other hand, is able to live but fails to prosper in isolation.

As the author points out, this is not a clear case of parasitism where the fungus lives purely at the detriment of its insect host. In return for its enforced hospitality the fungus very generously provides minute houses in which the insects live and by which they are protected from the attacks of their natural enemies. Under this arrangement, which is referred to by the author of the book as a symbiotic relationship, many of the individual insects must sacrifice themselves to the well being of the fungus, but others that are not so sacrificed receive the protection of the fungus and in turn are able to reproduce their kind and thus continue their own existence, at the same time insuring the continual existence of their fungus protector.

<sup>1</sup> The university of North Carolina Press, Chapel Hill.

Mycologists will find this one of the most interesting volumes that has appeared in recent times, and the author is to be congratulated on his valuable contribution to science.—F. J. SEAVER.

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NOTES ON THE LIFE OF PERSOON<sup>1</sup>

Christian Daniel Persohn came from the island Usedom in the Baltic Sea off the coast of Pomerania. He landed at the Cape of Good Hope in 1749. He worked as a tailor. On the 21st of August 1757 he married Elizabeth Wilhelmina the daughter of Johannes Groenewald, a member of one of the old Dutch Cape families. The name was changed to Persoon. On the 31st of December 1762, their son Christiaan Hendrik Persoon was born. Four months later (May 8, 1763) the mother died. As early as 1760 Christiaan Daniel Persoon became an importer and dealer. He was moderately successful and for that time well off financially.

At the age of 13 (in 1775) Young Christiaan Daniel went to the Netherlands to begin his education. After six weeks in Amsterdam, he went to Lingën. The intention was to prepare himself so that later he could pursue a theological course. He paid 50–60 guildens for room, board and laundry at the Seminarium in Lingën.

In April 1776 young Persoon's father became seriously ill and died on the 22nd of the same month. Christiaan Hendrik Persoon inherited better than 36,000 Dutch guildens. As guardian for the boy, the father appointed the "Board for the Care of Orphans" of his city. At that time young Christiaan Hendrik's financial troubles began. His inheritance had not been paid him ten years after he became of age, due to the remissness or, as it was claimed, the dishonesty of his guardians. Fortunately the Committee for Orphans in Amsterdam kept him from actual want by advancing money which was not remitted from home on time. On the advice of a friend he gave power of attorney to two men at the Cape. Of the 10,000 guildens paid these men, by his guardians, he never received one penny.

When he was 22 (in 1784) he gave up the study of theology, because of poor health and went to Halle to study medicine. Soon

<sup>1</sup> A resumé of an article by J. L. M. Franken in Vol. XV, Afl. 4 of the *Annale Van Die Universiteit Van Stellenbosch*. (Capetown) 1937.

he went back to Lingen and was on the point of giving up his studies entirely. However, later he went to Gottingen. In 1786 he was studying at the University of Leiden, but was back in Gottingen in 1788. He remained there till the fall of 1799. In March 1799 he received the degree of Doctor of Philosophy from the "Kaiserlich-Leopoldinisch-Carolinische Deutsche Akademie der Naturforscher." He traveled in Germany, France and Switzerland. In 1802 he went to Paris. The income from his publications was small, and he soon was suffering from extreme poverty. He lived in a small room on the sixth floor. In 1823 a friend offered to get subscriptions from friends and colleagues, but Persoon refused to even consider this. Through the intervention of Dr. Kirchhoff of Antwerp, the government of Holland gave him a pension of 800 guildens per year. In return Persoon donated his herbarium of 14,000 plants which was sent to the University of Leiden.

In 1834 (only two years before his death) he was visited by Franz Junghuhn, the Humboldt of Java, with an offer to go to Java. He was startled to see a shrunken little man, with gray hair and a tangled beard. His eyes were watery, inflamed and blinking. This was the prince of mycologists, who lived then at No. 2 Rue des Charbonniers, in the neighborhood of the present Gare de Lyon. In the cemetery Le Père Lachaise is a worn tombstone with the inscription:

PERSOON  
CHRETIEN HENRY  
Botaniste

Né au cap de Bonne Espérance  
Décédé le 15 Novembre 18—

To quote Fee: "Thus lived and died perhaps the greatest genius Mycology has ever known, for Persoon was a builder. He began the work with practically nothing and left a system of which others have availed themselves with much too little acknowledgement."—

RICHARD DE ZEEUW.

## MYCOLOGICAL SOCIETY OF AMERICA

## SUMMER FORAY

The Mycological Foray will be held in the Great Smoky Mountain National Park, but with headquarters at Gatlinburg, Tennessee. In view of the fact that the meetings will be held from August 17th to 20th inclusive, during the tourist season, it is advisable that those planning to attend make reservations early at one of the following places, all within the radius of a mile:

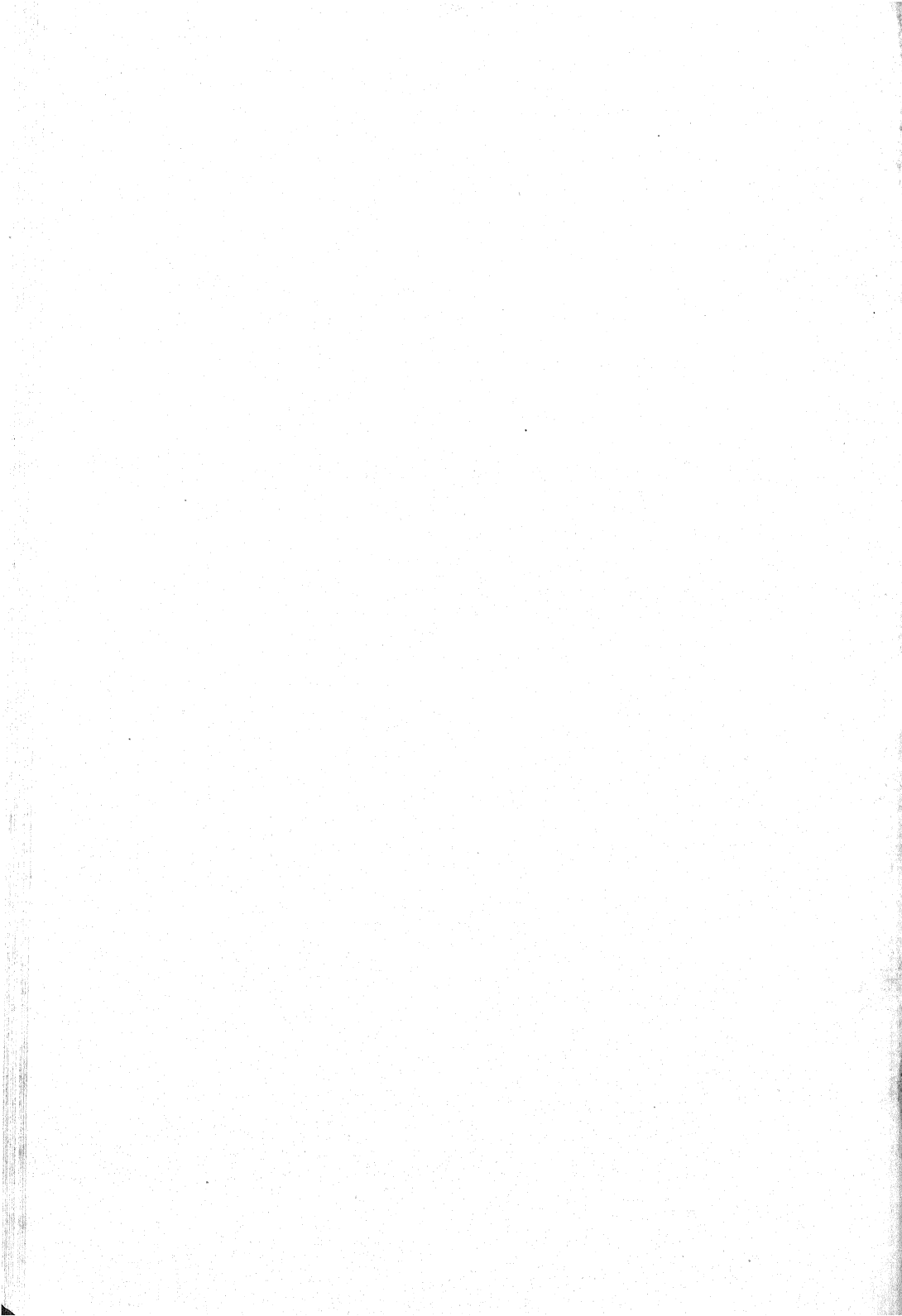
Mountain View Hotel .....	\$4.00	up	AM*
Riverside Hotel .....	3.00	up	AM
Leconte View Lodge .....	1.50		EM
Smoky Heights Resort .....	1.00	up	EM
Gateway Tourist Cabins .....	1.25	up	E
Water Cress Cabins .....	1.50	up	E
Reagan's Cabins .....	1.00		E
Laurel Springs .....	1.00	up	E
King Cabins .....	1.00	up	E
Huff's Tourist Cabins .....	1.25	up	E
Dewey Ogle's Cabins .....	1.00		E
Ross Moore Tourist Home ...	1.00	up	E
M. & O. Tea Room .....	1.00	up	EAM
Indian Gap Hotel and Cabins..	2.00	up	A
Maples Manor Hotel .....			no information as is new

Because of the great differences in elevation, 5,800 feet between lowest and highest elevations, and because of the richness of the flora, the region should be of intense interest to those desiring to collect, and of equal interest to those who enjoy mountain scenery. Furthermore, it is reported that some of the best trout fishing in the east is to be found here, and it is urged that those who desire to follow this sport first obtain fishing regulations from the Park Superintendent at Gatlinburg.

Gatlinburg may be reached via routes U. S. 19, N. C. 107, and Tenn. 71 from Asheville, North Carolina, and by way of Tenn. 71 from Knoxville, Tennessee. Additional road information may be obtained from maps furnished by the larger oil companies. The Louisville & Nashville and the Southern Railways serve Knoxville and the latter railroad also Nashville, and from these two places Gatlinburg is reached by bus.—DAVID H. LINDER.

\* A: American plan; E: European plan; M: meals served.





# MYCOLOGIA

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## CHARDONIELLA—A NEW GENUS OF THE UREDINALES<sup>1</sup>

FRANK D. KERN

(WITH 3 FIGURES)

In March 1937, Dr. C. E. Chardon sent me from Colombia a fine specimen of rust which he had labeled as being on *Gynoxis*, a genus of the Compositae known from the Andes of tropical South America. It was natural to think at once of *Chrysopsora Gynoxidis* described by Lagerheim from Ecuador many years ago (Ber. Deuts. Bot. Ges. 9: 345. 1891). But *Chrysopsora* has ring-shaped sori of a low pulvinate form. The rust at hand had elongated hair-like sori. It did not have any of the external characters of *Chrysopsora*.

This fact made one suspicious of the host determination. Then began an effort to get additional material so that the host could be checked carefully. The attempt was successful and finally a specimen was obtained with flowers and rusted leaves on the same shoot. I am indebted to Dr. S. F. Blake for his examination of this specimen. He confirmed the determination of *Gynoxis* but was unable to name the species with the material at hand.

The macroscopic characters of the rust, as already indicated, made a reference to *Chrysopsora* impossible. Microscopic characters confirmed this. *Chrysopsora* has two-celled spores with an internal promycelium. Our specimen has one-celled spores with an external promycelium. The spores are borne on stalks 80–125  $\mu$  or more long.

<sup>1</sup> Contribution from the Department of Botany, The Pennsylvania State College, No. 118.

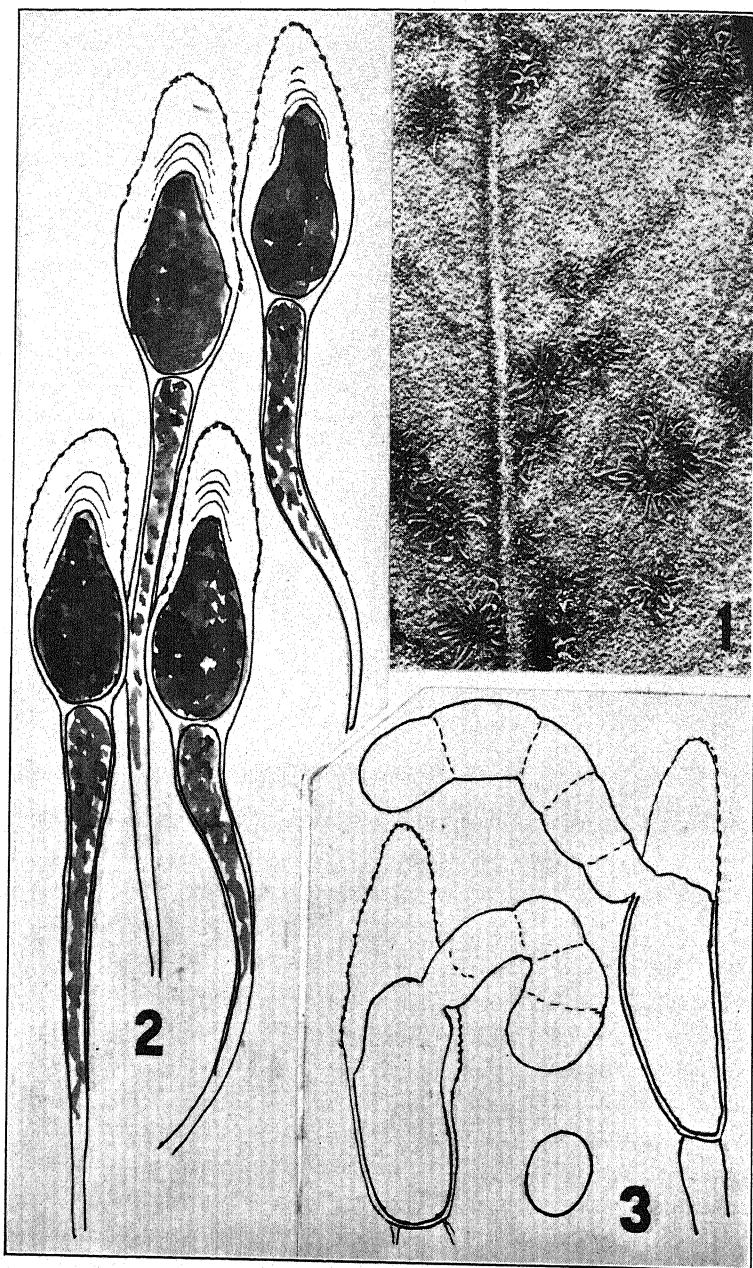


FIG. 1, microphotograph of telia on the undersurface of leaf,  $\times 3$  (photo by Dr. L. O. Overholts); 2, four teliospores, with their long pedicels, illustrating the manner in which the spores are crowded together in the sorus; 3, two spores germinating, showing the 4-celled promycelia, below—the outline of a single basidiospore.

With stalked spores more or less united laterally we have characteristics of the family Pucciniaceae. To place it in a tribe is not so easy. It has some of the characters of the Puccinosiirae except that the spores do not seem to be in chains. If they are in chains then what I interpret as stalks are long intercalary cells. These cells are filled with orange-yellow contents as are the spores themselves. The contents give a coarsely granular appearance and large oil droplets are evident.

I have tried to see a resemblance of this *Gynoxis* rust to the genus *Trichopsora*. But *Trichopsora* has spores in chains, with an evenly thick wall, and an internal promycelium. This specimen has stalked spores, with wall much thicker above, and an external promycelium. The resemblance to *Trichopsora* seems to be superficial only. There is an external resemblance to *Cronartium* or *Cionothrix* but those genera have small spores in evident chains without either stalks or intercalary cells. Again the resemblance is purely a superficial one.

I have pleasure in dedicating this new genus to Dr. Carlos E. Chardon, who has contributed so much to our knowledge of the rusts and other fungi of the tropics of the western hemisphere.

### **Chardoniella** gen. nov.

Pycniis subepidermalibus; periphysibus instructis. Teliis subepidermalibus, erumpentibus in columellam plus minus elongatam cylindraceam vel filiformem, massam siccam corneamque formantibus, teliosporis unicellularibus pedicellatis; promycelio externo typice 4-cellulari.

### **Chardoniella Gynoxidis** sp. nov.

Pycniis epiphyllis, in centro macularum decoloratarum aggregatis, profunde insidentibus, globosis vel piriformibus, 175–225  $\mu$  latis; periphysibus fasciculatis, prominentibus, 80–100  $\mu$  vel longioribus.

Teliis hypophyllis, in greges coronarias 1–5 mm. diam. dispositis, columellam elongatam cylindraceam formantibus, 2–2.5 mm. longis, flavis vel aureo-flavis; teliosporis ellipsoideis vel obovatis, 24–32  $\times$  55–69  $\mu$ , infra rotundatis vel truncatis, supra plerumque angustatulis; membrana hyalina, 1–1.5  $\mu$  cr., ad basim leve, ad apicem valde incrassata, 19–26  $\mu$ , obscure laminata; pedicello hyalino, in parte inserta 12–15  $\mu$  lato, deorsum attenuato, sporae duploaequante vel longiore. Basidiosporis late ellipsoideis, 15–16  $\times$  19–23  $\mu$ .

Hab. in foliis *Gynoxidis* spec., Cerro Montserrate pr. Bogota, alt. 2750 m., Colombiae, mense Martii, 1937, C. E. Chardon (no. 829).

# A STUDY OF SOME AQUATIC PHYCOMYCETES ISOLATED FROM MEXICAN SOILS<sup>1</sup>

FRED T. WOLF

(WITH 4 FIGURES)

Although Butler (1907) discovered more than thirty years ago that species of *Pythium* could be isolated from the soil, it was not until the application of Butler's cultural methods by Harvey (1925) that the widespread occurrence of the Saprolegniaceae and other water molds in the soil was generally appreciated. Subsequently, the phycomycetous soil flora has been studied in various parts of the world. Coker and Braxton (1926), Coker (1927), and Raper (1928) have made a series of studies of terrestrial forms of the Saprolegniaceae and closely related groups in North Carolina, Couch (1927) has isolated aquatic fungi from soils in New York, and Harvey (1927, 1928, 1930) has investigated the water molds occurring in Wisconsin soils, as well as those of Oklahoma, Mississippi, and Kentucky.

The studies of Apinis (1930) in Latvia, Dissmann (1931) in Austria, Barnes and Melville (1932) in England, Cook and Morgan (1934) and Morgan (1938) in Wales, Höhnk (1935) and Richter (1937) in Germany, Nagai (1931) in Japan, and Cookson (1937) in Australia have shown that saprolegniaceous fungi as well as other groups of the aquatic Phycomycetes are widely distributed in soils throughout various parts of the world. These investigations have further demonstrated that while certain species previously found only in water are also quite common in the soil, other forms, including species of the genera *Brevilegnia* and *Geolegnia*, are apparently adapted for a strictly terrestrial mode of existence, and are to be found only as constituents of the soil microflora. Höhnk (1935) has clearly correlated the number of motile stages of the zoöspores in various genera of the Saproleg-

<sup>1</sup> Contribution from the Laboratories of Cryptogamic Botany and the Farlow Herbarium, Harvard University, No. 169.

niaceae with the aquatic and terrestrial habits of these forms. Cook and Morgan (1934) have even been so impressed by the wide distribution and common occurrence of the Saprolegniaceae in the soil as to suggest that the term "water molds" as a common name for these fungi will ultimately have to be given up.

Apparently no collections of the aquatic Phycomycetes have ever been made in Mexico, either from water or from soil. During August, 1937, sixty samples of Mexican soils, chiefly from river beds and other moist situations, were collected by the author. The territory represented by these collections extends along the Pan American Highway (Camino Nacional no. 1) from Laredo, Texas to Mexico City. In addition, a number of collections were made in the vicinity of Cuernavaca. Inasmuch as the territory from which collections were made is a large, sparsely populated one, and towns or other suitable landmarks were often lacking, the "mileposts" along the highway, giving the distance (in kilometers) to Mexico City were often used to designate the localities from which soil samples were collected. The approximate locations of the sources of the soil samples from which aquatic fungi were isolated may be seen from the accompanying map (FIG. 1).

The soil samples, collected in small glass vials, were subsequently brought into the laboratory, placed in sterile Petri dishes, covered with sterile distilled water, and boiled hemp seeds were introduced as a substratum. From eleven of the soil samples cultured in this manner, aquatic Phycomycetes, including representatives of the Blastocladiaceae, Saprolegniaceae, and Leptomitaceae, were isolated. The present paper, concerned with the identity, morphology, and development of these fungi, is based upon a study of hemp seed cultures over a period of nine months.

The family Blastocladiaceae was represented by six isolates, all belonging to the genus *Allomyces* (Butler, 1911). These *Allomyces* isolates were studied culturally and biometrically by Dr. Ralph Emerson, at the Botany School, University of Cambridge, England, to whom the author is indebted for practically all of the information presented herein concerning them.

Emerson (1937, 1938) has demonstrated the existence in the genus *Allomyces* of three distinct types of life cycles, and has therefore proposed the classification of the various species into

subgenera based upon their life cycles. All species of *Allomyces* produce thin walled sporangia, as well as the characteristic thick walled resistant sporangia. In the subgenus *Euallomyces*, which includes *A. javanicus* Kniep (1929, 1930) and *A. arbuscula* Butler

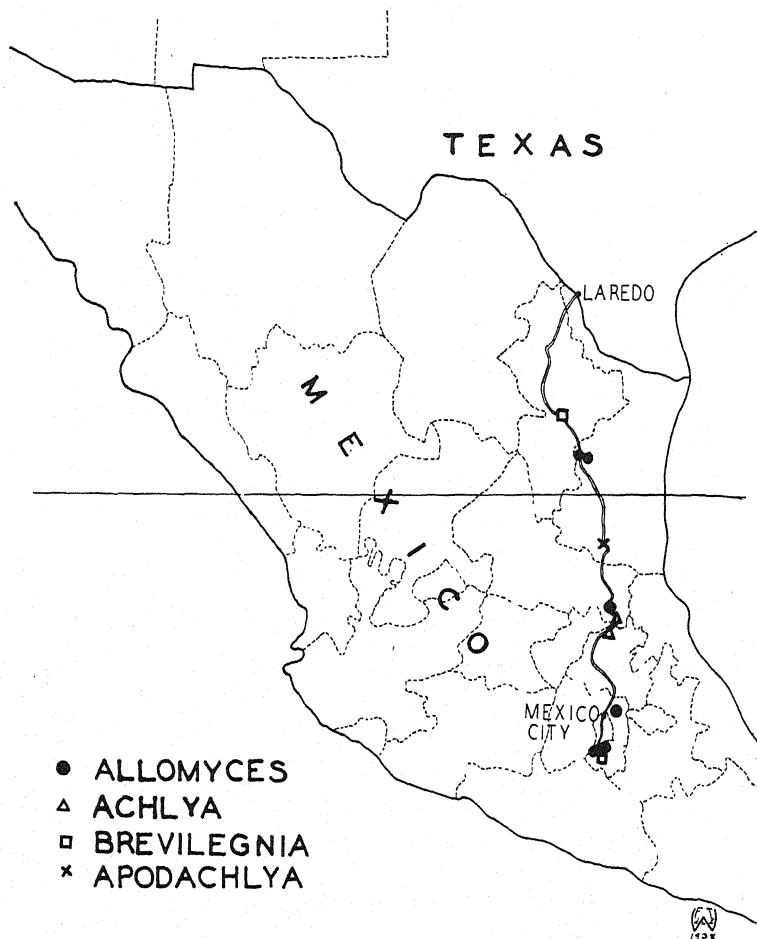


FIG. 1.

(Hatch, 1933, 1935), zoöspores from germinating resistant sporangia develop into plants bearing male and female gametangia. There is thus a regular alternation of asexual and sexual generations in this life cycle. In the subgenus *Cystogenes*, on the other hand, which includes *A. moniliformis* Coker and Braxton (1926),

zoöspores from resistant sporangia encyst upon emergence, and the cysts germinate to give rise to groups of four zoöspores, each of which develops into an asexual plant bearing resistant sporangia. These two subgenera are further differentiated upon the basis of the pitting of the walls of the resistant sporangia: in *Euallomyces*, the pits are fine and closely spaced, whereas in *Cystogenes* the pits are larger, more prominent, and more widely spaced. A third subgenus, *Brachyallomyces*, has been tentatively proposed for a number of isolates which apparently have no sexuality and do not form cysts. These forms are characterized by the complete omission of the gametophyte generation from the life cycle.

Observational evidence, confirmed by a series of 100-150 measurements of the length and width of the resistant sporangia of the Mexican isolates of *Allomyces*, showed that the six isolates fell into three morphological types. It may be observed (FIGS. 2, 3) that measurements of the resistant sporangia of isolates no. 26, no. 29, and no. 37 are in close agreement, while isolates no. 16 and no. 17 are very similar to each other, and isolate no. 46 differs markedly from the others. These differences are further borne out by an examination of the pitted walls of the resistant sporangia (FIG. 4). Isolates no. 16, no. 17, no. 26, no. 29, and no. 37 have resistant sporangia whose walls are provided with the fine, closely spaced pits characteristic of the subgenera *Euallomyces* and *Brachyallomyces*. In isolate no. 46, however, the wall of the resistant sporangium has larger, more obvious, and more widely spaced pits, as in the subgenus *Cystogenes*.

Supplementary to the morphological studies of the asexual, resistant sporangium-producing plants, attempts by Dr. Emerson to secure germination of the resistant sporangia were successful in four of the six isolates, so that complete life cycles were obtained. These four isolates can therefore be definitely identified. Germination experiments with resistant sporangia of the remaining two isolates have not yet been carried out in sufficient number to justify specific designation.

The following species of the genus *Allomyces* (Blastocladiaceae) were collected:



## ALLOMYCES ARBUSCULA Butler (1911)

Two collections were made of this species. One (no. 29) was collected from moist soil in the Borda Gardens, Cuernavaca, on August 16, 1937; the other (no. 37) was found in a roadside ditch near Tepexpan, 6 km. east of Venta de Carpio, on August 18. As may be seen from the data presented (FIGS. 2, 3, table 1)

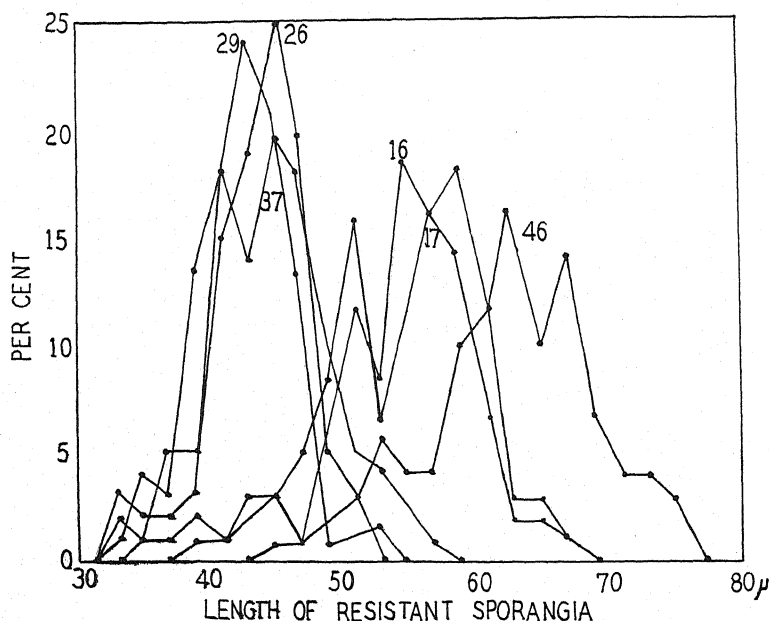


FIG. 2. Length of the resistant sporangia of the various isolates of *Allomyces*.

TABLE 1

COMPARATIVE MEASUREMENTS OF THE RESISTANT SPORANGIA  
OF THE ISOLATES OF *Allomyces*

Isolate	Number of measurements	Mean width ( $\mu$ )	Mean length ( $\mu$ )	75% or more between	
				Width ( $\mu$ )	Length ( $\mu$ )
<i>A. arbuscula</i> (No. 29)....	100	33	43	28-38	38-48
<i>A. arbuscula</i> (No. 37)....	100	33	45	28-38	40-50
<i>A. anomala</i> (No. 26)....	100	33	44	28-37	38-48
<i>A. moniliformis</i> (No. 46)...	100	35	63	31-38	54-70
<i>A. sp. indet.</i> (No. 16)....	150	42	56	33-48	45-61
<i>A. sp. indet.</i> (No. 17)....	150	42	55	34-48	46-61

resistant sporangia of these two isolates are very similar to each other in size. The walls of the resistant sporangia are ornamented with the pitting characteristic of *Euellomyces*. Upon germination of the resistant sporangia of these isolates, zoöspores were produced which gave rise to sexual plants bearing gametangia characteristic of *A. arbuscula*. The brightly pigmented male gametangia are hypogynous in position, as described for this species by Hatch (1933, 1935).

ALLOMYCES ANOMALA Emerson (1937, unpublished)

This species was isolated (no. 26) from soil collected on August 16 from the Borda Gardens, Guernavaca, a locality in which *A. arbuscula* was also found. As regards the size of the resistant sporangia and characteristics of their pitting, this isolate is indistinguishable from *A. arbuscula*. Upon germination of the resistant sporangia, however, the zoöspores invariably give rise to asexual plants. A sexual stage is presumably entirely omitted from the life cycle, as is apparently the case in at least one species of the closely related genus *Blastocladia* (Blackwell, 1937).

This isolate clearly belongs, therefore, to the subgenus *Brachyalomyces*. There is but a single species, *A. anomala*, based on two collections made by Emerson, one from Stowe, Texas, and the other from Hupeh, China. Whether or not other early isolates of *Allomyces*—such as the original form of Butler (1911)—which were studied before the discovery of sexuality in the genus, may actually belong to this species, remains problematical.

ALLOMYCES MONILIFORMIS Coker & Braxton (1926)

This rare species of *Allomyces* was collected once (no. 46) from the Rio Axtla, at its intersection with C. N. 1, 399 km. north of Mexico City, on August 20. Resistant sporangia of *A. moniliformis* (FIG. 2, 4) are more elongate than in other species of the genus, and a large proportion of these thick walled sporangia are bluntly pointed at the apex, in marked contrast to the broadly rounded shape of the resistant sporangia of *A. arbuscula*. Furthermore, the pitting of the walls of the resistant sporangia is of the larger, more obvious, more widely spaced type as described above.

The life cycle of isolate no. 46 conforms to that described for the subgenus *Cystogenes*—to which *A. moniliformis* belongs—by Emerson (1937, 1938). Although the resistant sporangia are slightly larger than in the original material described by Coker and Braxton (1926), it seems clear that the present isolate is actually *A. moniliformis*.

This species has previously been found only in North Carolina, by Coker and Braxton (1926) and Coker (1927).

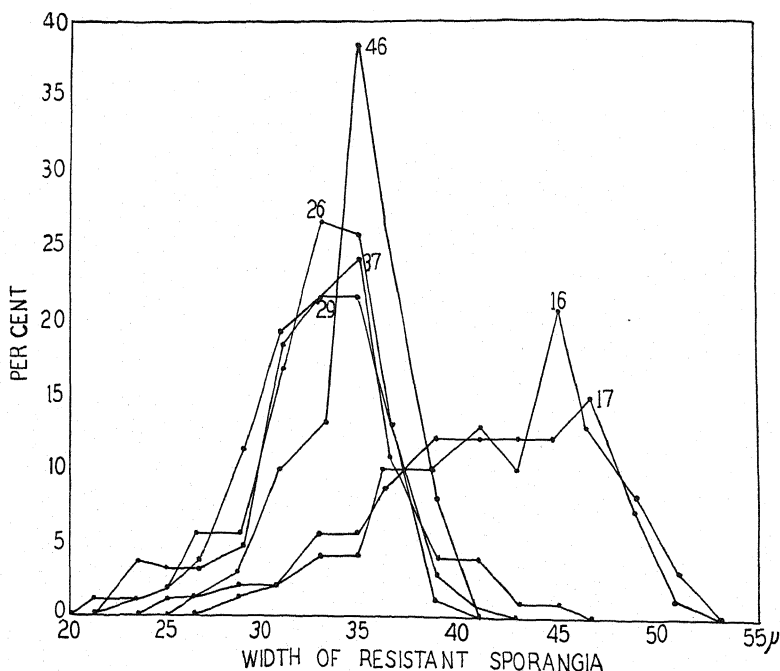


FIG. 3. Width of the resistant sporangia of the various isolates of *Allomyces*.

#### ALLOMYCES sp. indet.

Two isolates (no. 16, no. 17) from soil collected at the Rio Pilon at its intersection with C. N. 1, 833 km. north of Mexico City, on August 13, belong to an undetermined species of *Allomyces*. Resistant sporangia from these two collections are so similar to each other in size and appearance that the two isolates are very probably identical. These resistant sporangia are consid-

erably larger than in the Mexican material of *A. arbuscula* and *A. anomala*, and the pitting is of the type characteristic of the subgenera *Euallomyces* and *Brachyallomyces*, as contrasted with *Cystogenes*.

Since resistant sporangia of these two isolates have proved difficult to germinate, experiments to determine the life cycle have not yet been successful. If a sexual stage is ultimately found, it will probably be of the *A. arbuscula* type, as no species with

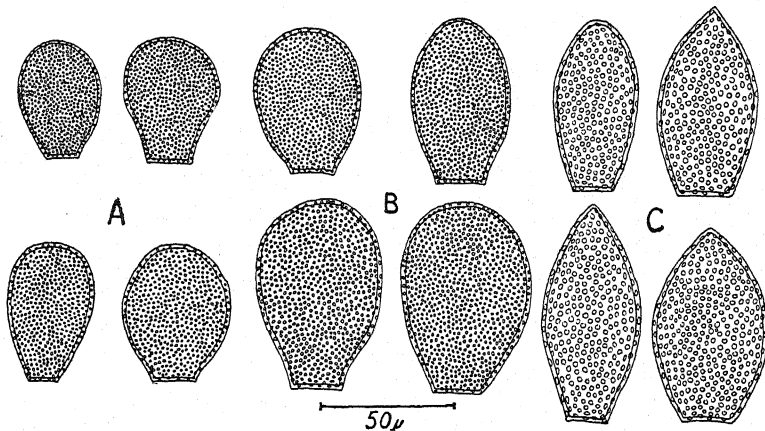


FIG. 4. Resistant sporangia of the isolates of *Allomyces*. A, *Allomyces arbuscula* (resistant sporangia of the isolate of *A. anomala* are indistinguishable from these); B, *Allomyces* sp. indet.; C, *Allomyces moniliformis*.

epigynous male gametangia has as yet been found in the western hemisphere (Emerson, 1937). There is also the possibility, as seems more probable, that these isolates represent unusually large forms of *A. anomala*, or that they may belong to an undescribed member of the subgenus *Brachyallomyces*.

In addition to the species of the Blastocladiaceae just discussed, a few forms belonging to the Saprolegniaceae were also collected:

#### ACHLYA CONSPICUA Coker (1923)

This species was collected once (no. 48) from soil near the Rio Coy, at its intersection with C. N. 1, 444 km. north of Mexico City, and once (no. 53) from soil in an arroyo intersecting C. N. 1, 501 km. north of Mexico City, on August 20. Both collections

were found to agree closely with Coker's original description. *A. conspicua* has previously been isolated from soil in North Carolina (Coker, 1927).

BREVILEGNIA DICLINA Harvey (1927)

This species was collected once (no. 10) from soil near the Rio de Montemorelos, at the intersection of C. N. 1, 915 km. north of Mexico City, on August 13. It appears to be fairly widely distributed in soils in various parts of the United States (Harvey, 1930) and has also been reported from Europe (Cook and Morgan, 1934).

BREVILEGNIA SUBCLAVATA Couch (1927)

This species was found once (no. 28) in soil from the Borda Gardens, Cuernavaca, on August 16. *B. subclavata* has previously been collected only by Couch from Long Island, New York, the source of the material from which the species was originally described. The very dense, compact, restricted growth on hemp seed, the short-clavate shape of the sporangia, the non-motility of the spores, and the characteristics of the sexual organs in the Mexican isolate were found to agree in all essential features with Couch's original description.

The family Leptomitaceae is represented in the present series of collections by a single species of *Apodachlya*:

APODACHLYA PYRIFERA Zopf (1888)

This species was isolated (no. 60) from soil collected near the Rio Frio, at its intersection with C. N. 1, 587 km. north of Mexico City, on August 20. The sporangia of this isolate are somewhat variable in size and shape, and the zoöspores regularly encyst at the mouth of the sporangium upon emergence. This represents the first instance known to the author in which this species, previously known from water in Europe, New York, and Massachusetts, has been found to occur in the soil.

DISCUSSION

Inasmuch as no studies of the aquatic Phycomycetes of Mexico have been made prior to the present report dealing with only a

few of the soil forms, no very general conclusions may yet be drawn. There are, however, a few points of interest in connection with this relatively small number of collections, even though the latter cannot be considered to offer more than a fragmentary picture of the phycomycetous soil flora of the region.

The small proportion of successful isolates from the soil samples collected by the author may be explained by the fact that the samples were kept for a period of six weeks before an opportunity to culture them was obtained. This delay would also seem to explain the great preponderance of isolates of *Allomyces*, ordinarily considered a relatively rare genus, in the present collections. The presence in *Allomyces* of thick walled resistant sporangia afford it a much greater chance of survival under adverse conditions than is obtained with forms having no such structures adapted for persistence.

*Allomyces* is primarily a genus of the warmer climates. Various species have been found in the tropical regions of both the eastern and western hemispheres (Kniep, 1929, 1930; Emerson, 1937), and the northernmost limit of its range is reached in Wisconsin and New York. In view of these facts, it does not appear surprising, therefore, that species of *Allomyces* seem to be of rather common occurrence in Mexico. Since *A. moniliformis* has been reported from North Carolina and from Cuernavaca, Mexico, there is reason to believe that this species is not of rare occurrence, and future studies will disclose other intermediate localities in which it is to be found.

The distribution of *Brevilegnia dictina*, previously known from various parts of the United States and from Europe, and of *B. subclavata*, previously found only in New York, also indicate a notable lack of endemism in the distribution of these aquatic fungi.

There are undoubtedly many more species of aquatic fungi to be found in Mexico. Such places as the floating gardens at Xochimilco, in which the water is rich in organic matter and plant refuse to furnish likely substrata, would seem to offer an exceedingly favorable collecting ground for future investigation.

## SUMMARY

No previous studies have been made of the aquatic Phycomycetes of Mexico. From a series of sixty soil samples collected from various localities in Mexico in August, 1937, the following aquatic fungi were isolated:

Blastocladiaceae—*Allomyces arbuscula*, *A. anomala*, *A. moniliformis*, and *Allomyces* sp. indet.

Saprolegniaceae—*Achlya conspicua*, *Brevilegnia diclina*, and *B. subclavata*.

Leptomitaceae—*Apodachlya pyrifera*.

The study of these collections was begun with the support of an Alumni Research Fellowship from the University of Wisconsin, and was completed at Harvard University during the tenure of a National Research Fellowship. The writer is deeply appreciative of the collaboration of Dr. Ralph Emerson in studying the isolates of *Allomyces*. Nor would the completion of the author's portion of this investigation have been possible without the continued encouragement and helpful suggestions of Dr. E. M. Gilbert and Prof. Wm. H. Weston, Jr., under whom this work was done.

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CAMBRIDGE, MASS.

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## FIVE NEW ZOOPAGACEAE DESTRUCTIVE TO RHIZOPODS AND NEMATODES

CHARLES DRECHSLER

(WITH 5 FIGURES)

Five fungi referable to the Zoopagaceae are herein described as new, increasing the number of species presented as members of that family to thirty-eight. A sexual stage has so far been observed in only one of the five forms. As the form in question appears most closely allied to *Stylopaga araea* Drechsl. (4) occasion is taken to submit also a brief account dealing with the sexual stage of the latter species, supplementing the earlier characterization based on its vegetative and asexual reproductive phases. Among the new fungi not known to produce zygospores is included a species that in adaptation to an endoparasitic development within nematodes, gives rise to conidial apparatus which differs markedly from any hitherto represented in the group and thus makes necessary the erection of a new genus.

### STYLOPAGE SCOLIOSPORA

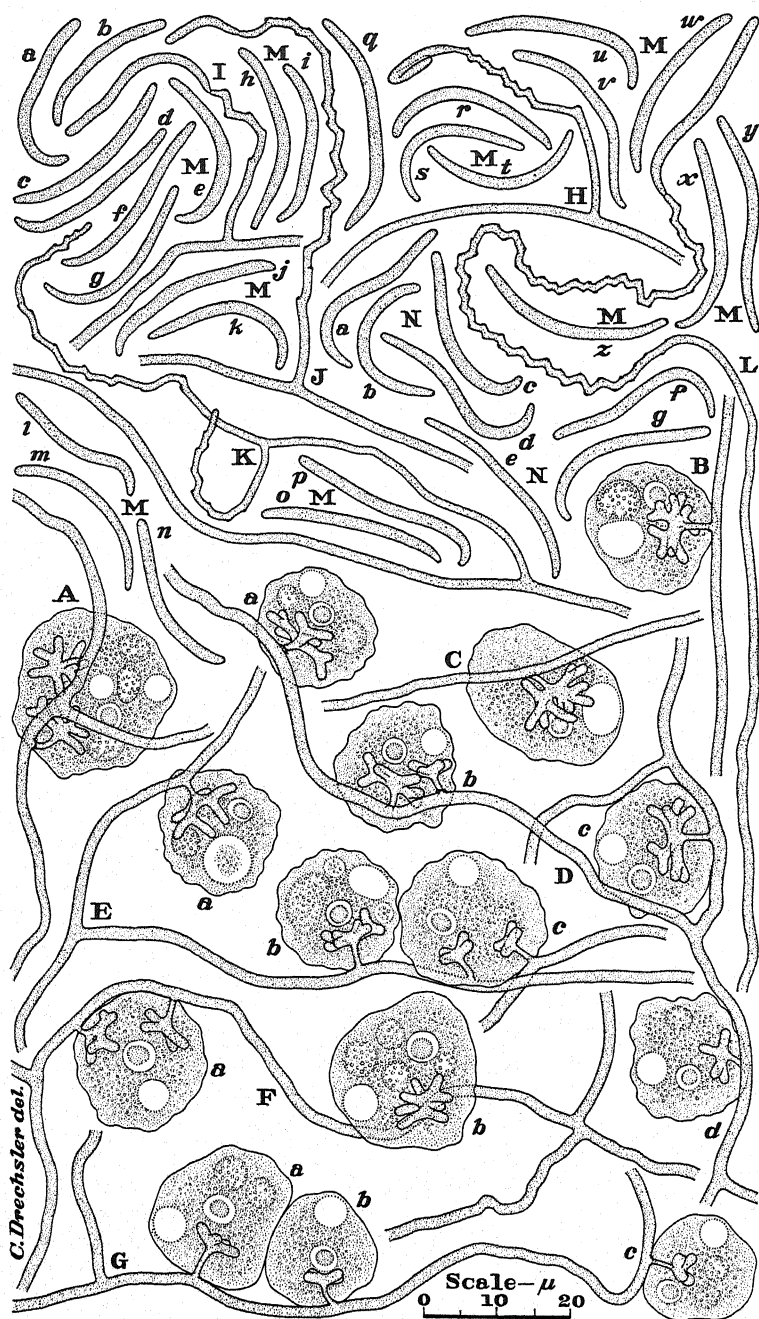
Watersoaked portions of submerged leaves and stems of water cress, *Radicula Nasturtium-aquaticum* (L.) Britten & Rendle, collected on May 13, 1938, from an extensive bed of declining productiveness near Woodstock, Va., gave rise, after being excised and planted on maize meal agar in Petri dishes, to mycelia of several species of *Pythium*. The mycelia in many of the isolation cultures soon became copiously overgrown with bacteria and infested with rhizopods in immense numbers. Later, some of the protozoan forms in the thriving microfauna, including a few that had appeared especially successful in establishing themselves, were virtually if not wholly exterminated through the activity of various members of the Zoopagaceae.

Perhaps not any of the ill-fated animals were more consistently visited by disaster than was an *Amoeba* measuring mostly from 13

to  $22\ \mu$  in diameter when drawn into its usual somewhat rounded shape, with contours curving sinuously about numerous delicate pseudopodial protrusions. Despite the small dimensions of the rhizopod, its enveloping pellicle was clearly visible in normal specimens, and persisted in recognizable condition for some time after removal of the protoplasm. In the slightly murky, dispersedly granular sarcode was imbedded a globose or somewhat ellipsoidal nucleus, mostly  $3$  to  $4.5\ \mu$  in diameter, inside the clear outer layer of which was regularly discernible a slightly darker roundish central part, or "Binnenkörper,"  $1.8$  to  $2.8\ \mu$  in diameter. A contractile vacuole and a small number of less conspicuous vacuoles, possibly digestive in function, provided additional though less distinctive structural features.

The *Amoeba* in question was captured through adhesion to the hyphae of a delicate aseptate branching mycelium (FIG. 1, *A*; *B*; *C*; *D*, *a-d*; *E*, *a-c*; *F*, *a*, *b*; *G*, *a-c*). Contact of little extent sufficed usually for the intrusion of a haustorium from the hypha into the animal (FIG. 1, *B*; *C*; *D*, *a*, *c*, *d*; *E*, *a*, *b*; *F*, *b*; *G*, *a-c*); somewhat lengthier contact permitting intrusion of two haustoria (FIG. 1, *A*; *D*, *b*; *E*, *c*; *F*, *a*). Whether single or plural, the absorptive organ was of the pedicellate type, consisting of narrow stalk and thickish dichotomously branched assimilative elements, exemplified in various species described earlier, as, for example, *Stylopaga rhabdospora* Drechsl. (7) and *S. cephalote* Drechsl. (10). After serving in the appropriation of all protoplasmic materials within the rhizopod, the haustorium was itself evacuated by the withdrawal of contents into the parent filament, its empty envelope thereupon becoming wholly invisible.

Asexual reproduction of the fungus took place abundantly through the development of conidia terminally, either on relatively short branches (FIG. 1, *H-K*), or sometimes on longer filaments (FIG. 1, *L*). Following the abscission of one spore, the sporophoric axis continued growth, usually somewhat obliquely, to give rise a short distance farther on to a second, the place of attachment of the first conidium being marked by a perceptible or often a pronounced geniculation. Repetition of the process, a familiar one in many groups of fungi, and already reported in several species of *Stylopaga*, here resulted often in extraordinarily prolonged

FIG. 1. *Stylopage scoliospora*.

fertile elements, showing from 50 to 75 slightly scarred geniculations, from each of which a conidium had been disarticulated. In the agar plate cultures studied, the conidiophorous branches were always found developing in prostrate positions on the surface of the substratum, never in erect positions. Though the possibility is not to be ignored that the recumbent posture may have been due to jostling by numerous nematodes, the obvious frailness of the sporiferous elements would seem in itself to have precluded an erect habit. As the material from which the fungus grew out was of aquatic origin, it seems reasonable to presume that in nature the frail elements are normally submerged. Their homology with the erect aerial conidiophores of terrestrial forms seems, however, sufficiently clear to permit assignment of the fungus to the genus *Stylopage*.

While the conidiophorous branches as a rule were perceptibly narrower than the predaceous filaments, the conidia borne on them approximated the vegetative hyphae in width; so that when strewn about on the substratum they presented an appearance as if they consisted of disarticulated mycelial segments (FIG. 1, *M*, *a-z*; *N*, *a-g*). Regarding such misleading appearance they invite comparison more particularly with the conidia of *Zoopage nematospora* Drechsl. (7), and as in that species the deceptive effect is heightened by the random curvatures that persist after disarticulation. Indeed, a term compounded of words meaning "crooked" and "seed," respectively, suggests itself as a fairly appropriate name for the fungus.

#### *Stylopage scoliospora* sp. nov.

Mycelium sparsum, ramosum; hyphis hyalinis, aliquantum irregulariter flexuosis, 1-2  $\mu$  crassis, ad animalcula inhaerentibus, pelliculam eorum perforantibus, haustoria singula vel subinde bina in ea introtrudentibus quae carnem exhauriunt; haustoriis pedicellatis, pedicello saepius 1-4  $\mu$  longo, 0.6-0.9  $\mu$  crasso, abrupte latescente, apice vulgo semel vel ter repetite bifurco, ita 2-8 rarius 10 ramos divaricatos 1-6  $\mu$  longos, 1-1.5  $\mu$  crassos ferente. Hyphae fertiles procumbentes, foris probabiliter in aqua immersae, modo 10-100  $\mu$  sed quandoque usque ad 500  $\mu$  longae, 0.8-1.6  $\mu$  crassae, ex apice conidium ferentes, deinde identidem repullulantset multa alia (subinde 50-75) conidia deinceps gerentes, ita mox crebre geniculatae; conidiis hyalinis, filiformibus, 20-32  $\mu$  longis, 1.3-1.9  $\mu$  crassis, saepius plus minusve curvatis.

*Amoebas* vulgo 13-22  $\mu$  latas capiens consumensque habitat in foliis caulibusque languidis *Radiculae Nasturtii-aquatici* prope Woodstock, Virginia.

Mycelium sparse, branching; vegetative hyphae colorless, somewhat irregularly flexuous, 1 to  $2\ \mu$  (mostly about  $1.5\ \mu$ ) wide, adhering to minute rhizopods, perforating the integument of each captive, and developing 1 or 2 haustoria inside to appropriate the fleshy contents; haustoria pedicellate, the pedicel often 1 to  $4\ \mu$  long and  $0.6$  to  $0.9\ \mu$  thick, abruptly widening and successively bifurcating at wide angles 1 to 3 times to terminate in 2 to 8 or more rarely in as many as 10 branches, 1 to  $6\ \mu$  long and 1 to  $1.5\ \mu$  wide. Conidiophorous hyphae prostrate, under natural conditions probably submerse, often 10 to  $100\ \mu$  and sometimes up to  $500\ \mu$  long,  $0.8$  to  $1.6\ \mu$  wide, after producing a conidium singly at its tip often repeatedly elongating from below the spore to give rise successively to many (sometimes 50 or 75) more conidia, whose places of origin after their disarticulation remain marked by geniculations mostly between  $1.5$  to  $5\ \mu$  apart. Conidia hyaline, filiform,  $20$  to  $32\ \mu$  (average  $26\ \mu$ ) long,  $1.3$  to  $1.9\ \mu$  (average  $1.6\ \mu$ ) wide, often more or less irregularly curved.

Capturing and consuming a species of *Amoeba* commonly 13 to  $22\ \mu$  in length and width, it occurs in moribund leaves and stems of *Radicula Nasturtium-aquaticum* near Woodstock, Va.

The apparent adaptation of the fungus to an aquatic existence, submerged or floating, would seem to strengthen the likelihood discussed in an earlier paper (3: p. 33-34), that the filamentous outgrowths noted by Leidy (13) on *Ouramoeba vorax* Leidy and *O. botulicauda* Leidy, by Korotneff (12) on *Longicauda amoebina* Kor., by Penard (14) on *Amoeba nobilis* Pen. and *A. vespertilio* Pen., as well as by Dangeard (1) on *Pelomyxa vorax* Dang., may prove to be referable to the Zoopagaceae. Geitler (11), in a recent and somewhat more detailed paper on the morphology and development of similar appendages found attached to *Amoeba proteus* Leidy, concluded that the fungus with which he was dealing unquestionably belonged in the Phycomycetes; though holding further that its position within that class, despite some similarities in outward habit to the Leptomitaceae, was presumptively in the Chytridiales, or more precisely, in the family Cladochytriaceae. An inspection of Geitler's figures, however, would seem to reveal not only a suggestive resemblance between the haustoria of his fungus and the haustoria more particularly of *Zoopage phanera* Drechs. (3), but also an even more provoking similarity between the repeatedly constricted filaments shown attached to *A. proteus*,

on the one hand and immature or growing conidial filaments of *Zoopage atractospora* Drechsl. (7) on the other. If Geitler's illustrations pertaining to the development of resting spores show little evidence of hyphal conjugation, the relationship of parts in one of them (11: fig. 3, r) yet invites comparison with immature sexual apparatus of *Z. cladosperma* Drechsl. (5).

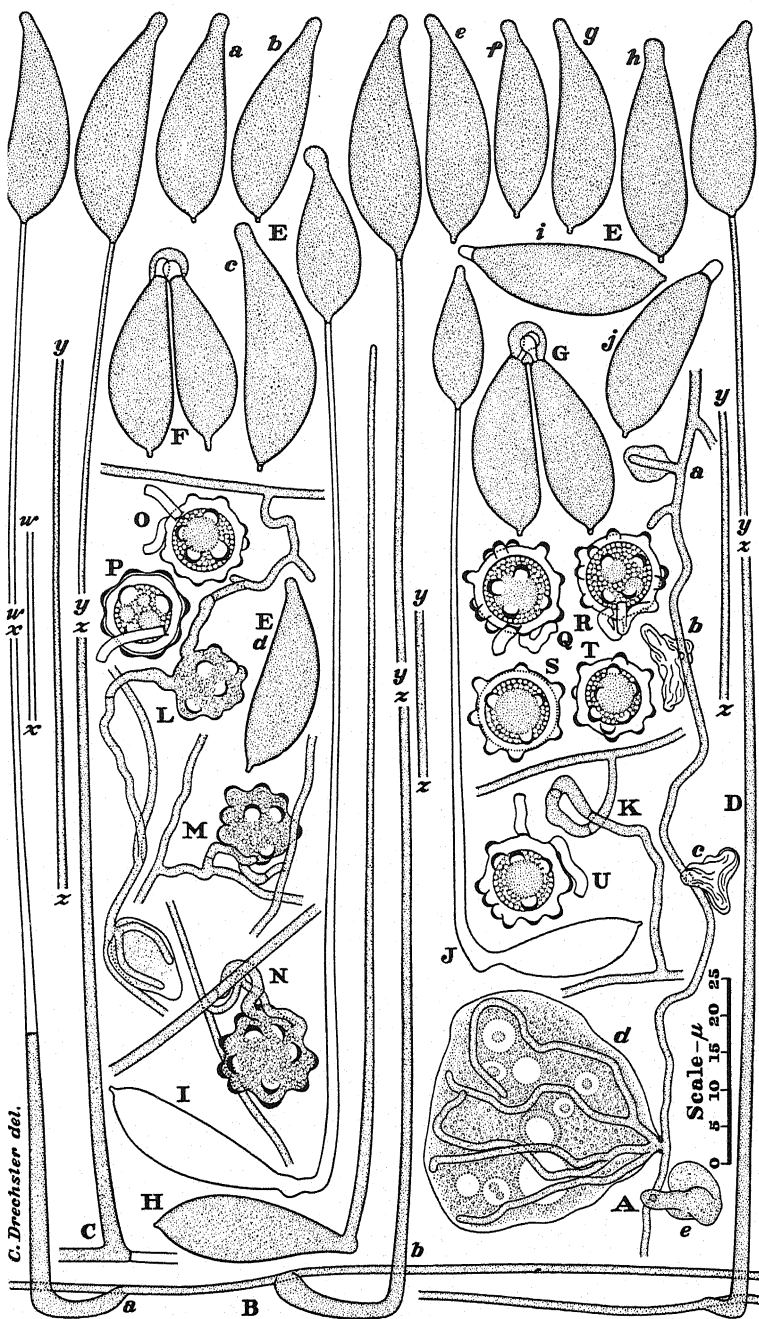
It must be admitted, of course, that the consistently aseptate condition imputed to the filamentous outgrowths by Geitler, as also by earlier writers, and the absence of any massive vegetative part comparable either to the spiral hyphae in the endoparasitic genera *Endocochlus* and *Cochlonema*, or to the greatly swollen conidia of the ectoparasitic genus *Bdellospora*, provide objections to a ready affiliation with the Zoopagaceae; yet these objections may perhaps be subject to abatement when they are considered in relation to the less exigent conditions attending development of *Amoeba* parasites in an aquatic as contrasted with a terrestrial environment. The spiral or globose vegetative thalli familiar in terricolous conidial parasites seemingly have as their special function the accumulation of protoplasmic masses in sturdy, compact bodies, little subject to injury from physical violence during the protracted period when the host remains capable of energetic locomotion. Delicate sporiferous filaments thrust out from an *Amoeba* briskly moving about among solid particles of harsh texture could hardly avoid suffering severe injury, if, indeed, they escaped being shorn off outright, perhaps at a relatively early stage. In a substratum of soil or decaying vegetable detritus, development of such filaments must accordingly be postponed until the animal has been disabled as a result of protoplasmic depletion brought on by the parasite itself. In a water medium, however, the danger from physical injury manifestly is so insignificant that external filaments can be produced from the beginning with complete safety; wherefore the need of rather massive storage structures in the form of obese vegetative thalli is wholly obviated. There is reason to presume, moreover, that while the slight disturbances usual in a water medium may be insufficient to injure a continuous filament destined for conversion into a conidial chain, they might readily suffice to bring about disarticulation of all conidia very soon after they became delimited by the deposition of septa at the constrictions;

in which event intercalary cross-walls would not often be encountered in the portions of filaments left attached, and their normal development in the filaments might therefore long remain unsuspected. As *Stylopage scoliospora* is a predacious mycelial form rather than an infective or parasitic one, and as it produces conidia separately rather than in chains, its usefulness in helping to interpret the problematical outgrowths reported by protozoölogists is less than might be desired.

#### STYLOPAGE RHYNCHOSPORA

A fungus with a reproductive habit most similar to that of *Stylopage araea* was observed in an old maize meal agar plate culture, which, after having been occupied by mycelium of *Pythium ultimum* Trow, had received the addition of some pinches of decaying vegetable rubbish collected on October 24, 1936, from a roadside ditch in Arlington, Va. On the hyphae making up its sparse mycelium Amoebae varying considerably in size were found attached (FIG. 2, A, a-e; L), some measuring as little in width as  $5\mu$  (FIG. 2, A, a), others as much as  $30\mu$  (FIG. 2, A, d). The contents of the smallest animals were assimilated by means of a simple haustorial branch, while expropriation of the larger specimens was accomplished through branched bush-like haustoria of the type represented in *S. araea* and *Zoopage mitospora* Drechsl. (10). With the depletion of protoplasm in each captured rhizopod, the haustorium was itself soon evacuated by withdrawal of its contents into the parent filament, leaving only the collapsed pellicle to supply visible evidence on the fate of the animal (FIG. 2, A, b, c).

As has been intimated, the conidiophores of the fungus, which were found sparsely distributed over the substratum, resemble the fertile hyphae of *Stylopage araea* in general stature; but whereas the latter arise abruptly from the parent mycelial filaments as narrow, only slightly tapering, erect stalks, the former branch off as relatively thick, mostly prostrate elements that become erect some distance from their respective attachments and taper markedly from wide base to narrow apex (FIG. 2, B, a, b; C; D). The sturdier development of the conidiophore would seem required here to support aloft a conidium of noticeably larger dimensions

FIG. 2. *Stylopage rhynchospora*.



than that of *S. araea*. Apart from its greater size the asexual spore of the present species is distinguished further by having its tip drawn out in a bluntly rounded beak (FIG. 2, *E*, *a-h*) that sometimes is later evacuated of protoplasmic contents and then becomes walled off as an empty appendage (FIG. 2, *E*, *i, j*). Often when two conidia, on falling to the substratum, happen to make apical contact with one another, their beaks are emptied of contents in secreting a mass of yellow adhesive material; so that the spores are, as it were, soldered or cemented together (FIG. 2, *F*, *G*). Whether the curious union thus effected, the like of which has not been seen in any related form, serves any useful purpose remains uncertain.

Repetitional development of conidia by the production of secondary (FIG. 2, *H*, *I*) and apparently even of tertiary (FIG. 2, *J*) conidia on germ sporangiophores is of frequent occurrence in the species. Just as in instances of similar development in the coarser congeneric forms, *Stylopaga hadra* Drechsl. (5) and *S. leiophya* Drechsl. (6), both destructive to nematodes, each derived spore is appreciably smaller than its parent.

The fungus was observed to produce sexual apparatus in moderate quantity. Conjugating branches invariably arise from separate mycelial hyphae. They unite apically with very little entanglement of parts (FIG. 2, *K*). A cross-wall is laid down in each of the sexual elements at some distance from the union, to delimit the paired gametangia. The young zygosporangium now develops at the union as a globose intercalary body that during its later stages of enlargement becomes boldly sculptured with warty protuberances (FIG. 2, *L-N*). At full maturity there is revealed within the outer sporangial envelope and generally rather intimately fused with it a thick zygosporangium wall, which surrounds a parietal protoplasmic layer of coarsely granular texture disposed about a central reserve globule of homogeneous consistency (FIG. 2, *O-U*).

A term compounded of two words meaning "snout" and "seed" respectively, is deemed suitable as a specific name for the fungus.

***Stylopaga rhynchospora* sp. nov.**

Mycelium sparsum, ramosum; hyphis hyalinis, flexuosis, plerumque 1-1.8  $\mu$  crassis, ad animalcula inhaerentibus, pelliculam eorum perforantibus, haus-

torium laxe arbusculiforme intus evolventibus quod protoplasma exhaurit. Hyphae fertiles incoloratae, ad summam erectae etsi in parte infera saepius procumbentes, 170–220  $\mu$  longae, basi 2–3.5  $\mu$  crassae, sursum attenuatae, apice 0.7–0.8  $\mu$  crassae, unicum conidium ferentes. Conidia hyalina, elongato-ovoidea, basi pediculo 1–2  $\mu$  longo circa 0.8  $\mu$  crasso praedita, apice rostro rotundato 2–3.5  $\mu$  longo 1.6–2.8  $\mu$  crasso subinde vacuo instructa, ex toto vulgo 27–34  $\mu$  longa, 7.5–10  $\mu$  crassa, saepius ex hypha fertile germinationis circa 120  $\mu$  alta conidium ordinis secundi modo 24–28  $\mu$  longum, 7.5–9  $\mu$  crassum proferentia; conidiis ordinis secundi ex hypha fertile germinationis 75  $\mu$  alta conidium ordinis tertii circa 19  $\mu$  longum 6.5  $\mu$  crassum subinde item proferentibus. Hyphae zygosporiferae 10–35  $\mu$  longae, 1–1.5  $\mu$  crassae, septo saepius 6–10  $\mu$  ab junctioe divisae, utraque ex alia hypha mycelii enata. Zygosporangia sphaeroidea, vulgo 10–12  $\mu$  crassa, maturitate 12–25 verrucis 0.8–2  $\mu$  altis 1.5–3  $\mu$  latis ornata, membrana cum membrana zygosporae flavidae quae cellulam viventem 7.5–9  $\mu$  crassam circumdat quasi concreta.

Amoebas vulgo 5–30  $\mu$  latas capiens consumensque habitat in reliquiis plantarum putrescentibus in Arlington, Virginia.

Mycelium branched, sparse; vegetative hyphae colorless, somewhat flexuous, mostly 1 to 1.8  $\mu$  wide, adhering to small rhizopods, perforating the pellicle of each captive and developing within it a bush-like branching haustorium to appropriate the protoplasmic contents. Conidiophores colorless, often procumbent at the base for a distance of 5 to 20  $\mu$ , then becoming erect, 170 to 220  $\mu$  in total length, mostly 2 to 3.5  $\mu$  wide in its proximal portion, tapering upward to a diameter of 0.7 to 0.8  $\mu$  at the apex, there bearing a single terminal conidium. Conidia colorless, elongated ovoid, 27 to 34  $\mu$  (average 30  $\mu$ ) in total length, 7.5 to 10  $\mu$  (average 8.9  $\mu$ ) in width, bearing basally a small pedicel usually 0.8  $\mu$  wide and 1  $\mu$  or rarely up to 2  $\mu$  long, distally drawn out into a bluntly rounded beak 2 to 3.5  $\mu$  long and 1.6 to 2.8  $\mu$  wide that may become evacuated, sometimes with secretion of yellow glutinous material causing cohesion in pairs tip to tip; often giving rise individually on a germ sporangiophore about 120  $\mu$  high to a secondary conidium usually 24 to 28  $\mu$  long and 7.5 to 9  $\mu$  wide; the secondary conidium in turn sometimes giving rise to a tertiary one, mostly about 19  $\mu$  long, and 6.5  $\mu$  wide, on a germ sporangiophore about 75  $\mu$  high. Zygosporic hyphae 10 to 35  $\mu$  long and 1 to 1.5  $\mu$  wide, those of a conjugating pair arising from separate mycelial filaments, each divided by a septum often placed 6 to 10  $\mu$  from the juncture. Zygosporangium intercalary, subspherical, at maturity boldly ornamented with 12 to 25 warty protuberances mostly 0.8 to 2  $\mu$  high and 1.5 to 3  $\mu$  wide, its wall often rather indistinguishably fused with the thicker wall of the yellowish zygosporae, which incloses a subspherical protoplast 7.5 to 9  $\mu$  in diameter.

Capturing and consuming Amoebae mostly 5 to 30  $\mu$  wide, it occurs in decaying remains of herbaceous plants in Arlington, Va.

THE SEXUAL STAGE OF *STYLOPAGE ARAEA*

During the several years that have intervened since it was first described, *Stylopage araea* has been observed from time to time in old plate cultures planted with decaying vegetable materials collected in Virginia and Maryland. Its mycelium and conidial apparatus were associated in some of these later cultures with sexual apparatus distinctive of the species. As in *S. rhynchospora*, and, indeed, in most allied forms whose sexual stage has come under observation, the zygothoric hyphae destined for conjugation with each other arise as branches, outwardly little differentiated, from separate mycelial filaments. On making contact the two branches wind about one another, each describing approximately two complete turns before apical fusion takes place (FIG. 3, *A*). A septum now is laid down in each of the intertwined branches, most often at a distance of 7 to 15  $\mu$  from the union; and the young zygosporangium begins to develop as a globose body, now virtually sessile (FIG. 3, *B*, *D*, *E*), now terminal on a stalk up to 10  $\mu$  long that may arise from near the union, or at a distance of 5 to 10  $\mu$  from it (FIG. 3, *C*, *F*). When the growing zygosporangium has attained or nearly attained a definitive diameter of 9 to 12  $\mu$ , it thrusts out 20 to 35 warty protuberances mostly about 0.7  $\mu$  high and 1.5  $\mu$  wide. It is then cut off by a basal septum (FIG. 3, *G*, *a*), and a zygosporangium wall is laid down, usually so close to the sporangial envelope that demarcation between the two membranes is little evident (FIG. 3, *G*, *b-j*). Reorganization of the living contents proceeds with gradual enlargement of two or three vacuole-like inclusions (FIG. 3, *G*, *b-e*, *g-i*) that eventually may coalesce into one; so that in its fully mature state the sexual body, always distinctly yellowish in color, incloses a subspherical protoplast 6 to 8.5  $\mu$  in diameter, composed of a parietal coarsely granular layer and a central reserve globule (FIG. 3, *G*, *f*).

*COCHLONEMA PUMILUM*

A fungus rather closely similar morphologically to *Cochlonema cylindricum* Drechsl. (9) appeared in a few old maize-meal-agar plate cultures on which had been planted some pinches of leaf mold collected on April 26, 1937, in deciduous woods in Arlington,

Va. It subsisted exclusively on testaceous rhizopods referable to the genus *Euglypha*, the animals utilized for food being, however, markedly smaller than *E. denticulata*, the species parasitized by *C. cylindricum*, measuring, as they did, only about  $11\ \mu$  in thickness,  $13$  to  $19\ \mu$  in width, and  $22$  to  $30\ \mu$  in length (FIG. 3, H-U). The elliptical scales making up the testae measured about  $5.5\ \mu$  in length and about  $2.5\ \mu$  in width; those bordering the mouth, usually 6 to 8 in number, being modified at the projecting end by very narrow marginal thickening and frequently, too, by some inconspicuous serrulation. A subspherical nucleus about  $5\ \mu$  in diameter and containing a globose body about  $1.3\ \mu$  wide frequently remained distinguishable during the earlier stages of infection (FIG. 3, H, K). From their morphology the animals, all very obviously conspecific, would seem best referable to *E. levis* (Ehrenb.) Perty as that species is set forth by Wailes (15), though I am inclined to doubt their identity with the rhizopod earlier and perhaps more correctly recorded under that binomial as being captured and consumed by *Dactylella passalopaga* Drechsl. (8). The specimens of *Euglypha* destroyed by the predaceous hyphomycete were uniformly of considerably larger dimensions, and showed generally a somewhat larger number of oral scales which individually appeared more heavily and more extensively thickened at the smooth projecting end. However, a similarity in general outward habit, certainly not shared by *E. denticulata* with its smoothly ovoid shape and very obscurely delimited mouth, would seem to sustain in some degree the application of one binomial to the two forms, encouraged, whether rightly or wrongly, by the broad species concept pervading much protozoological literature.

Infection of the small shelled rhizopod results from ingestion usually of a single rod-shaped conidium (FIG. 3, H). This conidium germinates by putting forth from one of its ends, often somewhat obliquely, a delicate germ-tube that soon widens into a thalloidic hypha (FIG. 3, I-M, T, U). In continuing growth the hypha becomes recurved, and thus acquires a strongly arched bail-like shape (FIG. 3, K, L, N, O, R, S), or even a convolute or circinate shape (FIG. 3, I, J, M, P, Q, T), depending on the measure of elongation. Apparently while the animal is still capable of locomotion, the thallus gives off a single reproductive filament from

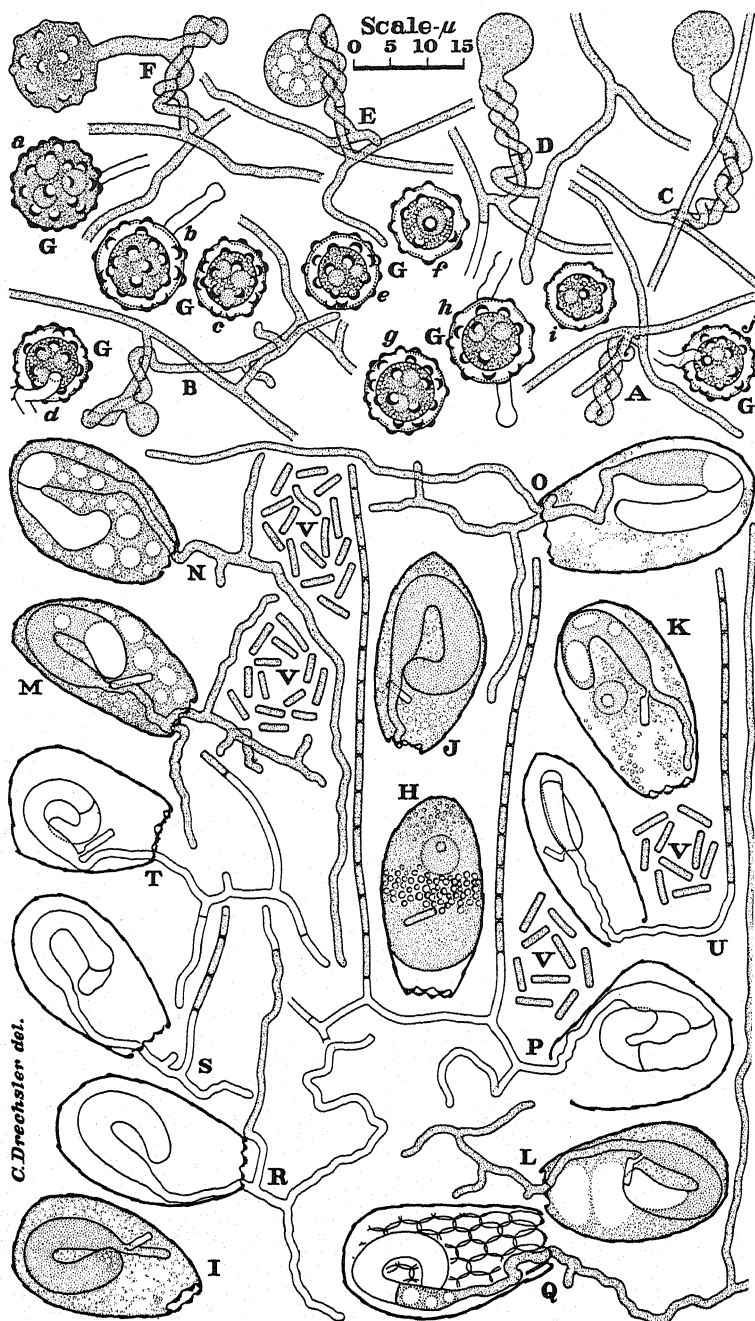


FIG. 3. A-G. *Stylopaga araea*; H-V, *Cochlonema pumilum*.

its proximal end, close to the attachment of the empty conidium (FIG. 3, *I-K*). After the animal is disabled this filament grows out through the oral opening, sends a few short branches into the substratum for anchorage (FIG. 3, *L, M*), and gives rise to one, two, or more rarely three aerial hyphae (FIG. 3, *N, O, Q*). These aerial hyphae elongate as protoplasm from the underlying parts of the fungus is transferred to them; but as the amount of nourishment available is always relatively small, their combined lengths ordinarily do not exceed  $350\ \mu$  or  $400\ \mu$ . Segmentation of the aerial hyphae converts them into chains of closely arranged rod-shaped conidia. In these chains the individual conidium is often very narrowly in contact with its neighbors by its slightly convex end-walls (FIG. 3, *P, S, U*). Disintegration of the conidial chains from slight disturbances leaves the spores strewn about on the substratum, ready to infect any specimen of the protozoan host that may unhappily ingest one of them. The somewhat shrunken, empty, curved thallic envelopes remaining inside the empty testae are usually rather inconspicuous (FIG. 3, *R*), but may often be discerned with less difficulty when they contain one or two cross-walls laid down in the course of their evacuation (FIG. 3, *P, S, T, U*).

The fungus, manifestly belonging to the genus *Cochlonema*, is held to be specifically distinct from *C. cylindricum*; the distinction being based more on the smaller dimensions of its conidia than on the dwarfish proportions of its thallus, wherein, to be sure, might merely be reflected the small bulk of the host animal.

***Cochlonema pumilum* sp. nov.**

Hyphae alitae incoloratae,  $20-40\ \mu$  longae,  $3-5\ \mu$  crassae, simplices, plerumque semel circulatim convolutae, ex basi per os animalis hypham genitabilem  $1-1.5\ \mu$  crassam proferentes, quae paucos brevis ramulos in materiam subjacentem intromittit et  $1-3$  hyphas fertilis erectas vulgo  $100-300\ \mu$  longas,  $0.9-1.1\ \mu$  crassas in aera emittit. Conidia hyalina, cylindrata, vulgo  $3-6\ \mu$  longa,  $0.9-1.1\ \mu$  crassa, utrimque leviter rotundata, in catenulas crebre digesta.

*Euglypham levem* forma minore enecans habitat in humo silvestri in Arlington, Virginia.

Vegetative hyphae colorless,  $20$  to  $40\ \mu$  long,  $3$  to  $5\ \mu$  wide, circularly or often circinately convolved in approximately one ( $0.7$  to  $1.3$ ) turn, each extending from its base and through the mouth of the host animal a reproductive filament  $1$  to  $1.5\ \mu$  wide, which sends a few short branches into the substratum outside and thrusts into

the air 1 to 3 conidiiferous hyphae 100 to 300  $\mu$  long, 0.9 to 1.1  $\mu$  wide; these hyphae collectively yielding in close catenulate arrangement often about 50 to 75 conidia of cylindrical shape with slightly convexed ends, measuring mostly 3 to 6  $\mu$  (average 4.6  $\mu$ ) in length and 0.9 to 1.1  $\mu$  (average 1.05  $\mu$ ) in width.

Destroying a small form of *Euglypha levis* it occurs in leaf mold in Arlington, Va.

#### COCHLONEMA FUSISPORUM

Including the fungus just described, three species of *Cochlonema* with rod-shaped conidia comprise all the members of the Zoopagaceae that have so far been set forth as developing endoparasitically in testaceous rhizipods. Several other congeneric forms, also producing rod-shaped conidia and likewise subsisting on testaceous rhizopods have been observed, even if as yet not in sufficient detail to allow an adequate discussion of them. Parasitism on shelled protozoans is, however, not limited to members of the series with cylindrical conidia, being shared unquestionably by a congeneric fungus with spindle-shaped conidia that appeared in an old maize-meal-agar plate culture two months after the addition of some pinches of leaf mold collected on November 22, 1937, in deciduous woods in Arlington, Va.

The fungus in question consistently parasitized an ovoid animal measuring usually 45 to 52  $\mu$  in length and 25 to 28  $\mu$  in width, which was covered with imbricated broadly elliptical scales often 7 to 8.5  $\mu$  long and 6 to 7  $\mu$  wide (FIG. 4, A, B). At the circular mouth the testa was fringed with a sharply dentate honey-colored band; near the fundus was contained a large spherical nucleus often 13 to 15  $\mu$  in diameter, within which a loose central assemblage of slightly darker oblong parts was discernible. Since the rhizopod thus conforms closely to the description of *Sphenoderia dentata* Pen. as given by Penard (14) and by Wailes (15), it may confidently be referred to that species. Apparently because of a rather dense texture of the animal's protoplasmic contents the thallus of the parasite was very often badly obscured, and consequently for the most part escaped notice until some development of hyphae outside betrayed its presence (FIG. 4, C-E). In specimens of the host containing numerous scales preparatory to divi-

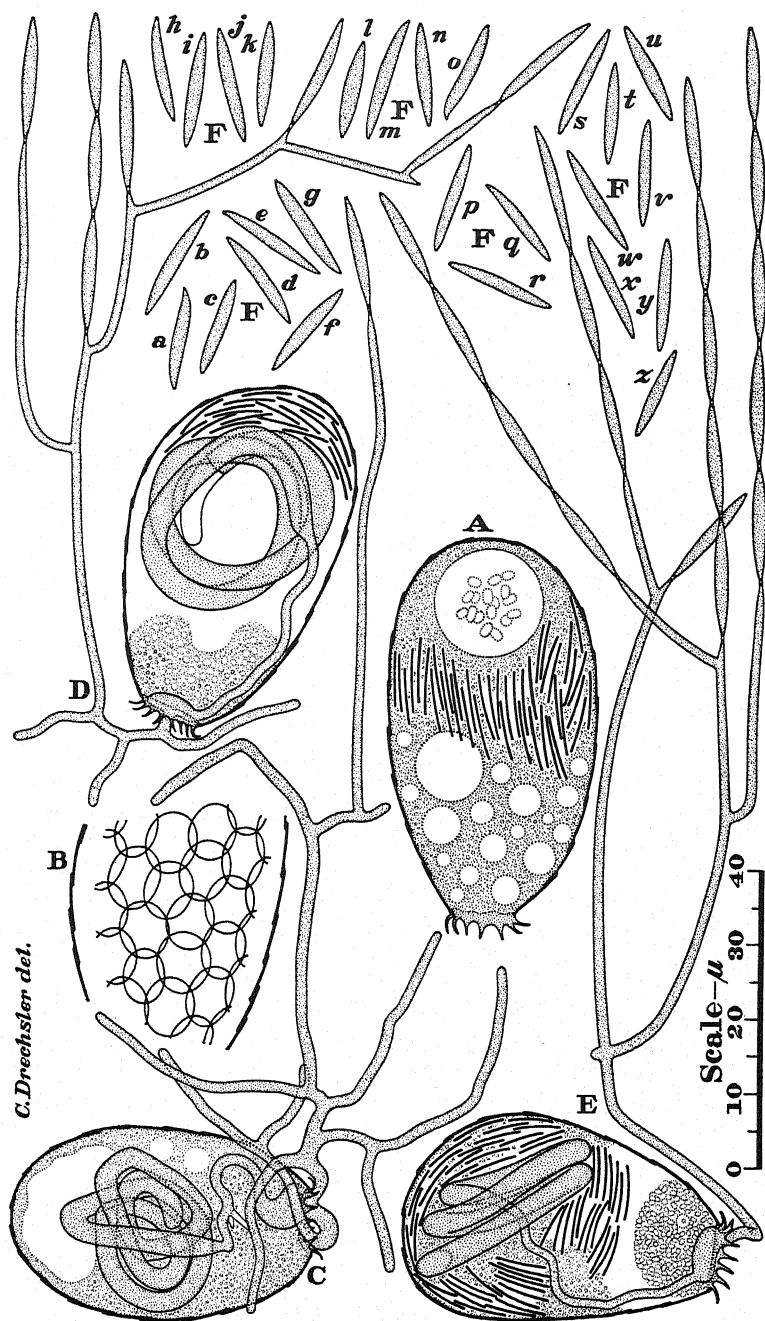


FIG. 4. *Cochlonema fusisporum*.



sion, the fungus could usually be detected earlier through conspicuous displacement of the plates from their normal position in a well ordered equatorial layer (FIG. 4, *D*, *E*).

The thallus appears usually of a bulk scarcely commensurate with the size of the parasitized animal. In the few instances where the vegetative body could be followed with certainty throughout its length, it was found to consist of an unbranched hypha, only moderately swollen, and coiled sometimes irregularly (FIG. 4, *C*), but more often with fair geometrical symmetry (FIG. 4, *D*, *E*), in only two, three, or four simple turns. The relatively small volume of the convolved structure is necessarily associated with comparatively early development of external parts; for only through such earlier development could the thallus be enabled after a brief initial period to function essentially after the manner of a haustorium in transmitting assimilated materials to conidial apparatus outside the host, instead of retaining them to augment its own volume. Now, as development of external parts requires the infected animal to be incapable of further locomotion, it follows that the fungus must somehow bring about early disablement of its host. A probable means by which such a result might be accomplished is to be recognized in a conspicuous gag-like enlargement of the reproductive hypha immediately within the animal's mouth (FIG. 4, *C-E*)—a curious modification not observable in allied forms, and assuredly well placed to interfere with or to disrupt the pseudopodial equipment of the rhizopod.

For the rest, the reproductive filament follows a usual course of development. It arises always singly from the proximal end of the thallus, reaches the oral opening of its host often by a somewhat circuitous path, and after emerging therefrom and in some instances sending a few short branches into the substratum, gives rise to erect or ascending aerial hyphae constricted at regular intervals. Through evacuation of protoplasm from the constrictions, and deposition of end-walls by the separated protoplasts, the aerial hyphae become converted into chains of spindle-shaped conidia, that, except for the absence of all sculpturing, recall the catenulate conidia of *Zoopage tryphera* Drechsl. (9). After the production of one chain of asexual spores, the supporting hypha often grows out somewhat obliquely from a point just below its

sharply tapered apex, to give rise a little farther on to a second conidial chain (FIG. 4, E), and frequently, by successive repetition of the process, to additional chains (FIG. 4, D). Apart from subterminal elongation, some increase in sporiferous hyphae is provided for through lateral branching (FIG. 4, D, E).

The shape of its conidium suggests for the fungus a name compounded of two words meaning "spindle" and "seed," respectively:

**Cochlonema fusisporum** sp. nov.

Hyphae alitae incoloratae, circa 150–175  $\mu$  longae, 2.2–3.8  $\mu$  crassae, simplices, bis vel quater circulatim convolutae, ex basi hypham genitabilem proferentes: hypha genitabili magnam partem 1–1.6  $\mu$  crassa sed in ore vel prope os animalis aliquantum inflata, ultra os in ramos fertilis erectos vel ascendentis 1.2–1.6  $\mu$  crassos abeunte; conidiis hyalins, levibus, fusiformibus, plerumque 12–17  $\mu$  longis, 1.5–2  $\mu$  crassis, in catenulas 15–35 sporas assurgentis digestis; ramo fertili deinde tum aliquotiens identidem repullulante aliquot additicias catenulas conidiorum deinceps fere gerente.

*Sphenoderia dentata* enecans habitat in terra silvestri in Arlington, Virginia.

Vegetative hypha colorless, often 150 to 175  $\mu$  long, 2.2 to 3.8  $\mu$  wide, simple, coiled in 2 to 4 circular turns 15 to 28  $\mu$  in diameter, from its proximal end emitting a reproductive filament; the reproductive filament mostly 1 to 1.6  $\mu$  wide except for an inflated part at the mouth of the host animal, outside of which orifice it terminates always in erect or ascending conidiiferous branches, besides sometimes giving off one or more short sterile branches into the substratum. Conidia colorless, smooth, spindle-shaped, mostly 12 to 17  $\mu$  (average 14.3  $\mu$ ) long, 1.5 to 2  $\mu$  (average 1.76  $\mu$ ) wide, formed in numbers of 15 to 35 in chains resulting from segmentation of the fertile branches; the basal part bearing a conidial chain often growing out repeatedly from below the pointed sterigmatic tip to give rise successively to additional conidial chains.

Destroying *Sphenoderia dentata* it occurs in leaf mold in Arlington, Va.

In the agar plate culture where *Cochlonema fusisporum* was found subsisting on *Sphenoderia dentata*, the rhizopod at the same time was being captured and consumed by the predaceous hyphomycetous form that I described earlier (2) as *Pedilospora dactylopaga*. Perhaps because the phycomycetous parasite rather quickly disables an infected animal, only one specimen of the rhizopod was seen undergoing simultaneous expropriation by both

fungi. Neither of the carnivorous species showed any ill effects from their close positional relationship.

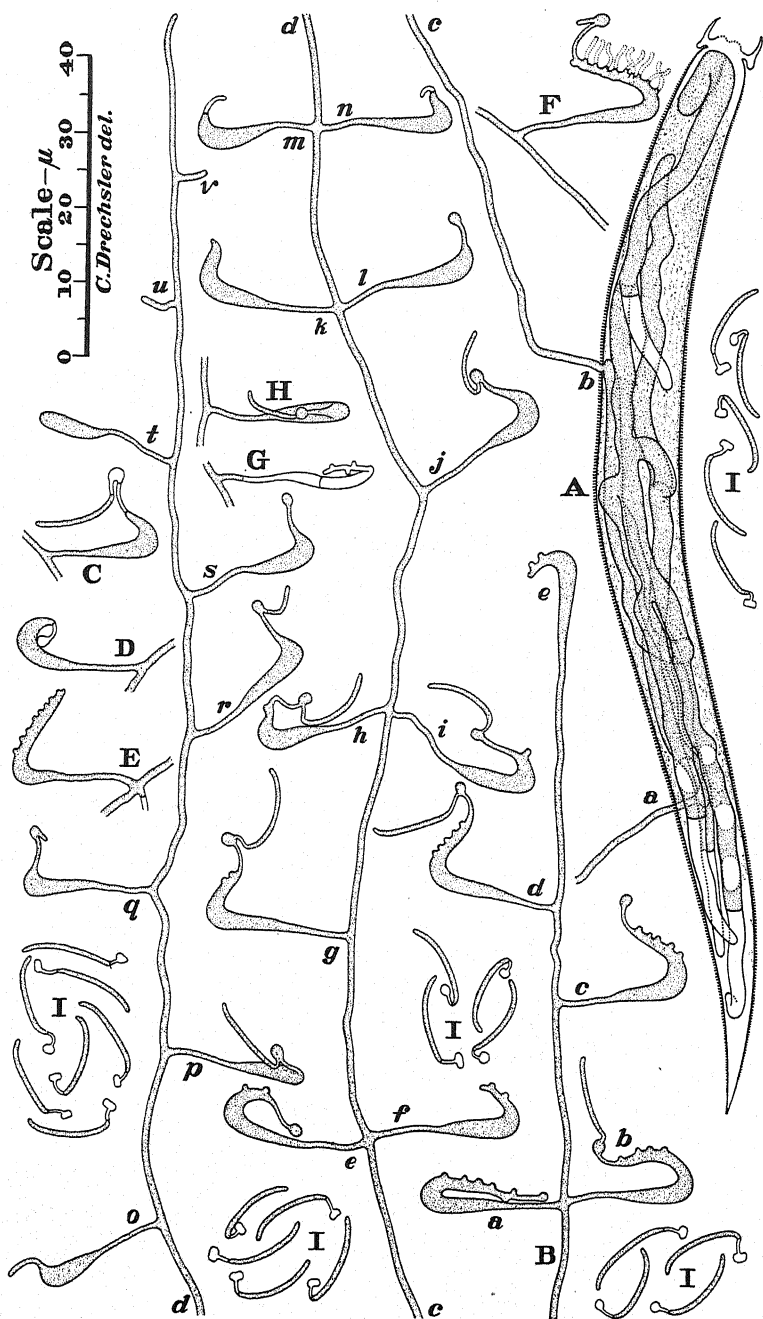
#### EURYANCALE SACCIOSPORA

Nematodes from their sculpturing obviously referable to a species of *Bunonema* were found being destroyed in considerable numbers on an old maize-meal-agar plate culture 4 weeks after it had been planted with some pinches of leaf mold gathered from deciduous woods in Arlington, Va., on March 25, 1938. The distinctive conidial apparatus growing out from the dead animals over the surface of the substratum indicated as the cause of the destruction an endoparasitic fungus comparable in reproductive habit and presumably, too, in biological relationship, to various species of *Harposporium* and *Verticillium* often exterminating large populations of eelworms. Previous to the death of affected nematodes and for some time thereafter, the oily or lumpy degeneration of all fleshy parts largely obscured the organism causing the pathological changes—a difficulty encountered, of course, in virtually all instances where nematodes are invaded by fungi. Later, on advanced depletion of the animal's degenerating contents, the vegetative thallus of the parasite was revealed as a branching filamentous mycelium disposed lengthwise within the sculptured integument, from blunt head to pointed tail. In the earlier observable stages the hyphae were found consistently devoid of septa; so that with respect to structure as well as with respect to dimensions, branching habit and texture of protoplasmic contents, they resembled the haustorial filaments of *Stylopage hadra* and *S. leiohypha*. In subsequent stages cross-walls were often present, having manifestly been laid down at intervals as retaining partitions to delimit living portions of hypha from empty portions. Evacuation of the mycelium was found to begin in the outlying elements, the dense finely granular protoplasm being utilized in extending a number of prostrate reproductive filaments over the substratum in various directions (FIG. 5, A).

These filaments originate as delicate branches from the endozoic mycelium, reaching the exterior by narrowly perforating the animal's integument. On attaining a certain length each gives rise some distance back from its tip and usually at an angle approxi-

inating a right angle, to a single prostrate branch (FIG. 5, *A, v, u*), or often to a pair of opposite prostrate branches. For a distance of 5 to 10  $\mu$  each branch maintains about the same width as the parent filament; then, however, while extending itself about 10  $\mu$  farther, still as a prostrate structure, it widens to a diameter three times greater (FIG. 5, *A, t*). Thereupon it abruptly changes its direction of growth to curve upward and thus to thrust into the air a narrowing beak at the end of which a small but readily noticeable bulbous enlargement is produced (FIG. 5, *A, s*). Sometimes from the adaxial side of this enlargement (FIG. 5, *A, j*), sometimes from its abaxial side (FIG. 5, *A, r*), yet as far as can be determined always approximately in the plane of the upcurved supporting branch, there is put forth a delicate filamentous outgrowth about 15  $\mu$  long, often bent rather abruptly about 2  $\mu$  from its attachment, and gently curved from the bend to the bluntly rounded tip. A cross-wall is now laid down immediately below the bulbous enlargement; and the enlargement, together with the short adjacent portion of outgrowth up to the abrupt bend, is evacuated by the migration of its protoplasm upward into the longer gently curved distal portion, which thereupon is set off by a retaining septum. Meanwhile the narrow vertical beak-like support below the bulbous enlargement likewise becomes evacuated through withdrawal of its contents back into the stouter portion of the upcurved branch, and a retaining septum is laid down to wall off the empty part (FIG. 5, *C*). When disarticulation then takes place at the partition immediately below the bulbous enlargement, a conidium is released, curiously made up of a slender curved cylindrical living cell together with an empty basal appendage that looks preposterously like a little pouch attached by a longish neck (FIG. 5, *I*).

After one conidium has been produced, the upcurved inflated branch grows out on its adaxial side a short distance below the septum delimiting it from its empty beak, to form a new beak on which after the same elaborate development already described (FIG. 5, *A, h, i*) another conidium is borne. Repetition of the process gives rise successively to a third conidium (FIG. 5, *A, g*), to a fourth, to a fifth (FIG. 5, *B, b*), to a sixth (FIG. 5, *B, d*), and sometimes even to a tenth (FIG. 5, *F*). With each successive elongation the blunt stump of the preceding sterigmatic beak is displaced,

FIG. 5. *Euryancale sacciospora*.

in most instances being pushed into an abaxial position (FIG. 5, *A*, *e-i*; *B*, *b-e*; *E*; *F*). Thus in the end the distal limb of the upcurved inflated branch, which may come to equal (FIG. 5, *B*, *a-d*) or even to exceed (FIG. 5, *E*, *F*) the proximal limb with respect to length, is usually revealed with a series of small dentate protuberances along its upper or abaxial side; the very delicate empty sterigmatic processes borne thereon (FIG. 5, *F*) having become almost indiscernible.

The axial reproductive filament develops after the manner of an indeterminate inflorescence (FIG. 5, *A*). As it continues to elongate it puts forth additional lateral branches at successive intervals, each branch emulating its older fellows in elaborating conidia one by one. Some dozens of sporiferous branches may be produced before axial growth is concluded with the development terminally of a broadened upcurved sporiferous part (FIG. 5, *B*, *e*) homologous with the lateral elements. Owing to the sequence of their formation, the older or proximal branches generally give rise to more conidia than the younger distal ones, though, to be sure, some branches outdistance others below them in productiveness, or, again, are exceeded in productiveness by branches above them. Elaboration of conidia naturally ceases when the vegetative thallus has yielded up all the protoplasmic materials resulting from appropriation of the animal's fleshy contents; the empty lateral branches (FIG. 5, *G*) then soon collapsing, and together with the evacuated envelopes of the other filamentous parts, becoming subject to disintegration.

Presumably the peculiarities of morphology and development embodied in its conidial apparatus, have a part in somehow adapting the fungus for parasitism on its host. The conidia in being formed a short distance above the substratum would seem favorably placed for making contact with the upper side of the habitually creeping animal, where adhesion, or perhaps other physical engagement, is facilitated by pronounced sculpturing of the integument. How the pouch-like conidial appendages may promote infection is more difficult to understand, unless through their flexibility they serve a useful purpose in entangling themselves, possibly with the somewhat rangy cephalic parts of the host, or possibly with its remarkable protuberances.

At all events the parasite manifestly differs so widely from all members of the Zoopagaceae hitherto described, that the erection of an additional genus within that family appears advisable. For this genus a name compounded of words meaning "wide" and "bent arm," respectively, is suggested by the swollen upcurving conidiiferous branches of the fungus; while the peculiar conidial appendages suggest a specific term made up from words meaning "small bag" and "seed," respectively.

### **Euryancale gen. nov.**

Mycelium continuum, ramosum, hyalinum, intra vivens animal crescens, in hyphis filiformibus consistens, post mortem animalis hyphas genitabilis extra evolvens; hyphis genitabilibus continuis, longiusculis, ramulos fertilis identidem emittentibus; ramulis fertilibus continuis, plus minusve incrassatis, ex apice conidia continua hyalina deinceps gerentibus.

Mycelium developing within living animals, continuous, branched, hyaline, composed of filiform hyphae, and giving rise after the death or disablement of the animal, to external reproductive filaments; reproductive filaments continuous, rather long, producing conidiiferous branches one after another; conidiiferous branches continuous, more or less widened, bearing continuous hyaline conidia terminally and often successively.

### **Euryancale sacciospora sp. nov.**

Mycelium in hyphis sterilibus leniter flexuosis plerumque  $2-3.5\mu$  crassis consistens,  $2-6$  hyphas genitabilis emittens; hyphis genitabilibus repentibus, saepius  $0.3-1$  mm. longis,  $0.8-1.2\mu$  crassis, quoque  $15-45$  ramulos fertilis ad pares angulos singulatum vel bifariam proferente; ramulis fertilibus inter se  $10-35\mu$  distantibus,  $18-30\mu$  longis, basi filiformibus repentibus  $0.7-0.9\mu$  crassis, sursum in aera abrupte recurventibus  $2.4-3\mu$  crassis, in sterigma plerumque  $3-4\mu$  longum  $0.7\mu$  crassum abeuntibus, ex eo unicum conidium gerentibus, deinde tum protoplasma ex sterigmate identidem subducto in alia sterigmata deinceps recrescentibus et ex eis alia conidia deinceps gerentibus; conidiis hyalinis, in cellula viventi superiore et appendice inani inferiore consistentibus: cellula viventi filiformi, leviter curvata,  $11-13\mu$  longa, circa  $0.7$  crassa; appendice basi ad instar sacculi inflata ibi saepius  $1-2\mu$  lata, sursum cervice  $1-2\mu$  longa,  $0.3-0.4$  crassa adjuncta.

Vermiculos generis *Bunonematis* enecans habitat in humo silvestri in Arlington, Virginia.

Mycelium composed of slightly flexuous hypha mostly 2 to  $3.5\mu$  wide, putting forth in various directions from each infected animal usually 2 to 6 creeping reproductive hyphae  $0.3$  to  $1$  mm. long and  $0.8$  to  $1.2\mu$  wide; each reproductive hypha giving rise at intervals of  $10$  to  $35\mu$  and at angles approximating a right angle, either singly or oppositely in pairs, to  $15$  to  $45$  conidiiferous

branches, which, measuring 18 to 40  $\mu$  in total length, consist individually of a prostrate proximal filamentous part, 5 to 10  $\mu$  long and 0.7 to 0.9  $\mu$  wide, together with a more expanded distal part 2.4 to 3  $\mu$  wide that curves abruptly upward into the air to terminate in a tapering sterigma, mostly 3 to 4  $\mu$  long and 0.7  $\mu$  wide, whereon is produced an apical conidium; the conidiiferous branch after withdrawing the protoplasm from one sterigma, often growing out into a new sterigma to bear another conidium, and then through continued repetition of the process frequently giving rise successively to additional conidia; conidium composed of a continuous, slightly curved, filiform, distal living cell, 11 to 13  $\mu$  long and 0.7  $\mu$  wide, together with a proximal empty appendage expanded at its base into a pouch-like part, 1 to 2  $\mu$  wide, and attached by a slender neck 1 to 2  $\mu$  long and 0.3 to 0.4  $\mu$  wide.

Destroying nematodes belonging to a species of *Bunonema*, it occurs in leaf mold in Arlington, Va.

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#### EXPLANATION OF FIGURES

FIG. 1. *Stylopage scoliospora*; drawn with the aid of a camera lucida to a uniform magnification;  $\times 1000$  throughout. *A*, portion of a branching superficial hypha from which two haustoria have been intruded into a relatively large specimen of the susceptible *Amoeba*; within the animal are visible also, firstly, the single subspherical nucleus consisting of a light peripheral layer together with a somewhat darker central body, secondly, two conspicuous contractile vacuoles (unstippled), and, thirdly, three digestive vacuoles somewhat obscured by overlying granular material; the three kinds of cellular structures being drawn in a manner uniform for all captured Amoebae shown in *A-G*. *B, C*, portions of hypha from each of which one haustorium has been intruded into a captured *Amoeba*. *D*, portion of mycelium with four captured Amoebae, *a-d*; one haustorium having been intruded into each of the three captives, *a, c*, and *d*, while two have been intruded into captive *b*. *E*, portion of mycelium with three captured Amoebae, *a-c*; one haustorium having been intruded into captive *a* and into captive *b*, while two have been intruded into captive *c*. *F*, portion of mycelium with two captured Amoebae, *a* and *b*; two haustoria having grown into the former, and one into the latter. *G*, portion of mycelium from which a haustorium has been intruded into each of the three captured animals *a-c*. *H*, a hypha with a conidiophorous branch showing a young terminal conidium in place, and thirteen geniculations that mark the places of attachment of conidia successively formed. *I*, portion of hypha whereon is borne a conidiophorous branch showing five geniculations and a fully grown sixth conidium attached terminally. *J*, portion of hypha with a conidiophorous branch showing a young conidium at its tip, subsequent to the formation earlier of nineteen conidia at successive positions marked by geniculations. *K*, portion of hypha with a branched conidiophore, the two elements of which show respectively ten and eighteen scarred geniculations, marking places of conidial attachment. *L*, portion of a long filament with conidiophorous termination showing a fully grown sixty-sixth conidium beyond sixty-five scarred geniculations that mark places of former attachment of successively developed conidia. *M, a-e*; *N, a-g*, conidia, showing variations in dimensions and shape.

FIG. 2. *Stylopage rhynchospora*; drawn with the aid of a camera lucida to a uniform magnification;  $\times 1000$  throughout. *A*, portion of mycelial hypha on which five individual Amoebae, *a-e*, are shown attached: one, *e*, having been captured so recently that penetration has not yet been effected;

two, *a* and *d*, having each been well invaded by a haustorium; the others, *b* and *c*, having each been wholly depleted of contents. *B*, a portion of superficial mycelial filament from which have arisen two conidiophores, *a* and *b*, each bearing a conidium; for want of space the conidiophores are shown in sections—*y* and *x* representing corresponding points on the sections of *a*; *y* and *z* representing corresponding points in the sections of *b*. *C*, a conidiophore bearing a conidium; from want of space shown in sections connecting at the points *y* and *z*. *D*, portion of mycelial hypha with a conidiophore bearing a conidium; from want of space shown in sections connecting at the points *y* and *z*. *E*, *a-j*, conidia, showing variations in size and shape. *F*, two conidia that have become united though cohesion of their glutinous beaks. *G*, two other conidia likewise united through cohesion of their glutinous beaks. *H*, a conidium germinating by the production of a conidiophore. *I*, a conidium that has given rise to a conidiophore whereon is borne fully developed a secondary conidium. *J*, a small conidium, presumably the product of repetitional development, that has in turn given rise to a conidiophore bearing a smaller and presumptively tertiary conidium. *K*, paired zygosporic branches immediately after apical fusion, showing in each one a septum at some distance from the union. *L*, *M*, *N*, three units of sexual apparatus showing successively later stages in enlargement and sculpturing of the zygosporangium; a filament from which one of the sexual branches in *L* is given off, has intruded a somewhat meager haustorium into a small animal captured by it. *O-U*, zygosporangia with zygosporoes in mature condition, illustrating variations in size and sculpturing; attached to them are shown portions of the empty sexual hyphae.

FIG. 3. Drawn with the aid of a camera lucida to a uniform magnification;  $\times 1000$  throughout. *A-G*, *Stylopaga araea*: *A*, pair of intervolved sexual branches arising from separate hyphae and conjugating by apical fusion. *B*, pair of sexual branches apically united, from which a young zygosporangium has begun to develop laterally at some distance from the union; the septum delimiting one of the gametangia is shown. *C*, sexual apparatus showing the half-grown zygosporangium developing on a stalk arising close to the juncture of the two intervolved sexual branches, in each of which a cross-wall delimits a distal gametangium. *D*, sexual apparatus like the preceding, but with the zygosporangium being developed on a shorter stalk. *E*, sexual apparatus with the zygosporangium sessile at some distance from the union, and nearly fully grown. *F*, sexual apparatus with the zygosporangium terminal on a rather long stalk arising at some distance from the juncture of the sexual branches; attainment of definitive size by the zygosporangium is accompanied by the appearance of warty protuberances. *G*, a, zygosporangium after delimitation of a basal septum, but before deposition of a thick oospore wall; *b-j*, zygosporangia containing zygosporoes—the thin warty envelopes of the former being fused rather indistinguishably with the thicker walls of the latter; showing, moreover, variations of the sexual bodies in size, in shape, in organization of contents, and in number and distribution of their warty protuberances. *H-V*, *Cochlonema pumilum*: *H*, partly encysted specimen of *Euglypha levis*, showing the animal's nucleus posterior to the equatorial granular zone, and an ingested conidium of the parasite in an anterior position. *I-K*, specimens of *E. levis*,

each containing a well developed thallus of the parasite; to the proximal end of each thallus is shown attached the empty envelope of the conidium from which it originated, together with the single reproductive hypha growing toward or through the animal's mouth. *L, M*, specimens of *E. levis*, each containing a thallus of the parasite that has given rise to a reproductive hypha, which after growing through the animal's mouth has ramified in the substratum outside; the development entailing evacuation of protoplasm from the distal portion of each thallus. *N, O*, specimens of *E. levis*, each containing a thallus of the parasite, from which has been produced a reproductive filament that after growing through the animal's mouth, has ramified outside to give rise to short sterile submerged elements and to longer aerial hyphae; evacuation of contents from the distal portion of each thallus having led to deposition of an approximately median septum. *P*, depleted testa of a specimen of *E. levis*, and within it the empty envelope of a thallus of the parasite, the protoplasmic contents of which were exhausted in the production of two conidial chains shown only in part from lack of space. *Q*, depleted testa of a specimen of *E. levis*, illustrating the dimensions and arrangement of its scales; within it is shown a thallus of the parasite that in large part has been evacuated of contents in giving rise to the reproductive filament with its lengthy aerial branch. *R-U*, exhausted testae of *E. levis*, each containing a thallus wholly depleted of contents in giving rise to conidial apparatus of which only the proximal parts are shown, owing to lack of space. *V*, conidia showing variations in dimensions and shape. (The testae of all animals in *H-T* are shown flatways; that in *U* is shown edgewise. Though the animals are mainly drawn in approximately median optical view, the oral profile is in most instances also shown, either wholly or partly; and in *Q*, besides, the testa is shown partly in surface view.)

FIG. 4. *Cochlonema fuisporum*; drawn with the aid of a camera lucida to a uniform magnification;  $\times 1000$  throughout. *A*, normal full-grown specimen of the host animal, *Sphenoderia dentata*, in a condition shortly preceding reproduction, showing the characteristically dentate oral fringe, the numerous scales for a new individual in the equatorial region, and the large nucleus in a posterior position. *B*, median portion of testa of *S. dentata*, illustrating the size and shape of its component scales, as well as their manner of imbrication. *C*, specimen of *S. dentata* containing a thallus of the parasite convolved in four turns; from its proximal end a reproductive filament has been produced; this filament, after widening markedly at the mouth of the host, resumed its original width on emerging therefrom to ramify outside; one of the resulting branches terminating in a chain of conidia, of which, from lack of space, only the basal member is shown. *D*, a specimen of *S. dentata* whose contents have been largely exhausted, and whose internal scales have been badly dislocated by the rather symmetrically convolved thallus of the parasite lying within, coiled in two and one-half turns; from the proximal end of the thallus has grown the single narrow reproductive filament, that, after swelling into a plug-like expansion at the animal's mouth, resumed its ordinary width on emerging therefrom, and gave rise outside to a few short submerged sterile branches as well as to a long aerial conidiiferous hypha; the latter, after producing a chain of conidia terminally, having grown out repeatedly four times from just below

each successive sterigmatic tip to produce in turn other chains of conidia farther on, exclusive of the one additional chain of spores produced on a lateral branch arising from the main axis some distance below its tip; the most distal of the chains not being shown at all from lack of space, the others being shown only in small part. *E*, specimen of *S. dentata* with protoplasm mostly exhausted and its scales inside badly displaced by a spiral thallus of the parasite consisting of two and one-third turns; from the proximal end of the thallus a single reproductive filament has been produced, which, after swelling into a plug-like distension at the animal's mouth resumed its ordinary width on issuing therefrom into the air, where, with two instances of lateral branching and two of subapical elongation, it gave rise to five chains of conidia, shown only in small part from lack of space. *F*, *a-s*, disarticulated conidia, showing variations in size and shape.

FIG. 5. *Euryancale sacciospora*; drawn with the aid of a camera lucida, to a uniform magnification;  $\times 1000$  throughout. *A*, specimen of *Bunonema* sp., permeated internally with a mycelium of the parasite; two reproductive hyphae, *a* and *b*, have been extended over the surface of the substratum—one of them, *b*, being shown from origin to growing tip, in three sections connecting at the points *c* and *d*; along the axial filament *b* are attached lateral conidiiferous branches, *e-v*, in early stages of development near the tip, and becoming progressively older toward the base. *B*, distal portion of a reproductive filament, showing four inflated upcurved lateral conidiiferous branches, *a-d*, on which sterigmatic stumps numbering six, four, five and five, respectively, indicate previous development and disarticulation of like numbers of conidia; the axial filament itself terminates in an expanded upcurved part, *e*, with two sterigmatic stumps on it implying disarticulation of two conidia. *C*, a swollen upcurving conidiiferous branch, with its first conidium shown in mature condition and attached to the empty slender sterigmatic prolongation. *D*, a conidiiferous branch from which its first conidium was detached somewhat abnormally, above rather than below the empty bulb-like part. *E*, a conidiiferous branch showing eight sterigmatic stumps. *F*, a conidiiferous branch supporting nine denuded sterigmata and terminating in a tenth sterigma on which a young conidium is being developed; the empty sterigmata, being only very indistinctly visible, are shown with dotted contours. *G*, an old conidiiferous branch from which the protoplasm has largely been withdrawn. *H*, upper view of conidiiferous branch in normal position, showing attached to it its first conidium still in somewhat immature condition. (Owing to some unavoidable disturbance incident to mounting material under a cover glass, nearly all other upcurved branches are shown as they appear when more or less flattened against the substratum; the unnatural postures, fortunately, revealing to advantage the actual relationship of parts.) *I*, conidia showing variations in size, in shape, and in disposition of the empty pouch-like basal appendages.

## OBSERVATIONS ON GASTERELLA LUTOPHILA

JOHN B. ROUTIEN<sup>1</sup>

In 1935, Zeller and Walker described a new uniloculate Gasteromycete, *Gasterella lutophila* Zeller & Walker,<sup>2</sup> which was placed in the Protogastrales.

In order to determine whether or not the fungus was to be found in Michigan, a number of collections of soil were made during the summer and fall of 1938. The soils were collected near East Lansing, Michigan, in two wood-lots of hardwood trees, from a cultivated field, under a willow tree on the campus of Michigan State College, from the bank of the Red Cedar River and from a grove of white pines; there was one collection from the bank of the Wabash River near Montezuma, Indiana.

In each case, soil from the top three inches was placed in a large culture-dish and saturated with sterile, distilled water. After a few hours, the excess water was poured off and the cover of the dish put in place in order to prevent the rapid loss of moisture. The dishes were kept in the dim, natural light of the laboratory; the temperature varied from 80° to 90°, sometimes 94° F. The soils were kept for a period of six weeks.

Any basidiocarps that appeared were collected at various stages of growth, killed, imbedded in paraffin, sectioned and stained.<sup>3</sup> After the fruiting-bodies ceased to develop, the soil was stirred slightly, more water was added and then poured off. In one case a few new basidiocarps appeared.

<sup>1</sup> The writer wishes to express appreciation to Dr. E. A. Bessey for his helpful advice and suggestions during the course of this study. He also thanks Dr. Leva B. Walker for her checking of the specimens and her suggestions regarding the nature of the fungus.

<sup>2</sup> Zeller, S. M. and Leva B. Walker. *Gasterella*, a new uniloculate Gasteromycete. *Mycologia* 27: 573-580. 1935.

<sup>3</sup> The killing agent was formol-acetic-alcohol, one of the reagents used by Zeller and Walker. The sections were stained with Heidenhain's iron-alum-haematoxylin; in some cases a counter-stain of light green or bismark brown was used.

Fruiting bodies developed after a period of three weeks on only two of the seven soils collected. Both of these collections were from one wooded area near East Lansing, Michigan. On the basis of this small number of collections, it seems that the fungus is limited to soil in the woods but is not always to be found there.

The specimens from Michigan fitted the description (based on plants from Nebraska) except for a few points. The fruiting-bodies from the former state were 300–400  $\mu$  in diameter, whereas those from Nebraska were 200–700  $\mu$  in diameter.

Several small specimens, when carefully removed from the soil, showed the presence of rhizomorphs. A few clamp-connections were visible on these rhizomorphs, but they were never seen on hyphae of the basidiocarp.

The spores of the type specimens were dark, lemon-shaped, verrucose and measured  $12\text{--}14 \times 10\text{--}12 \mu$ ; these measurements were obtained from permanent slides of the fungus. Of the two collections from Michigan, only one was like the description of *Gasterella lutophila* in regard to spore size, though all specimens showed the spores to be typically citriform and verrucose. In the other collection, the spores of sectioned fruiting-bodies measured  $14.5\text{--}(15.8)\text{--}16.2 \times 13.5\text{--}(14.2)\text{--}15.3 \mu$ , and the spores from a living basidiocarp measured  $17\text{--}(18.2)\text{--}18.7 \times 12\text{--}(16)\text{--}18.7 \mu$ . Also, pedicels ( $1.7\text{--}5 \times 1.7\text{--}2.5 \mu$ ) were found on about 15 per cent of the unfixed spores of this same collection.

The nuclear behavior in the basidium seems to be as outlined by Zeller and Walker; that is, the four nuclei formed as a result of meiosis apparently divide once more, and two to four of the resultant nuclei seem to enter the two to four basidiospores.

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## THE SYNONYMY OF FOMES FOMENTARIUS

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In connection with some current studies on the biology of *Fomes fomentarius* the senior author had occasion to compile the synonyms of this fungus. In most mycological literature the fungus is cited as *Fomes fomentarius* (L.) Gill., because Gillet published it as such in his *Les Champignons de la France* 1: 686. 1878. Gillet also is usually given credit for having raised Fries' sub-genus *Fomes* to generic rank.<sup>1</sup> However, it was found during the examination of mycological literature at the Farlow Herbarium that Kickx had made the same combination in his *Flore Cryptogamique des Flandres* 2: 237-238. 1867. In his mention of this fungus Kickx refers to Fries' work, "*Summa Vegetabilium Scandinaviae*, p. 321, 1849" where Fries designated the fungus as *Polyporus* (*Fomes*) *fomentarius* (L.). Thus Kickx recognized Fries' sub-genus *Fomes* and used it as a generic name. According to the International Rules of Nomenclature, Section 6, Article 42, this usage makes *Fomes* a valid generic name and the genus becomes *Fomes* (Fries) Kickx. The International Rules also state, in Section 3, that the starting point for nomenclature of this group of fungi, as well as some others, is Fries, *Systema Mycologicum*, 1821-32. Thus the name may be written as *Fomes fomentarius* (Fries) Kickx, or under Recommendation XXXII of this Code, authors earlier than the starting point of the group can be indicated "when useful or desirable" by the use of the word *ex*. Thus the fungus can also be designated as *Fomes fomentarius* (L. *ex* Fries) Kickx. The synonyms which the writers thus far have found in mycological literature are as follows: Synonymy of *Fomes fomentarius* (Fries) Kickx Fl. Crypt Flandres 2: 237-238. 1867.

<sup>1</sup> Ames, Adeline. A consideration of structure in relation to genera of the Polyporaceae. *Ann. Myc.* 11: 211-253. 1913.

Killermann, S. In Engler-Prantl, *Die Natürlichen Pflanzenfamilien* (2nd ed.) 6: 99-283. 1928.

- Boletus fomentarius* L. Sp. Pl. p. 1176. 1753.  
*Boletus fomentarius* L. Fl. Suecica (2nd ed.) p. 453. 1755.  
*Boletus unguilatus* Bull. Champignons de France p. 357-358. *pl.* 401, 491. 1791.  
*Boletus fomentarius* Pers. (spelled "fomontarius") Obs. Myc. 2: 1. 1799.  
*Boletus unguilatus* var. *salicina* Pers. Obs. Myc. 2: 4. 1799.  
*Boletus unguilatus* var. *quercina* Pers. Obs. Myc. 2: 4. 1799.  
*Boletus igniarius* Sowerby, English Fungi 2: *pl.* 132. 1799.  
*Boletus fomentarius* var. *ungulatus* Pers. Synops. Fung. p. 537. 1801.  
*Boletus fomentarius* var. *prunastri* Alb. & Schw. Conspectus Fung. p. 252. 1805.  
*Boletus fomentarius* var. *pomaceus* Alb. & Schw. Conspectus Fung. p. 252. 1805.  
*Boletus* (*Apus*) *fomentarius* Pers. Nees, Syst. Pilze Schwämme. 2: 57. 1817.  
*Polyporus fomentarius* Fries, Syst. Myc. 1: 374. 1821.  
*Polyporus fomentarius* Fries, Epicrisis p. 465. 1836-38.  
*Polyporus fomentarius* var. *excavatus* Berk. Ann. Soc. Nat. History 3: 387. 1839.  
*Polyporus* (*Fomes*) *fomentarius* Fries, Summa Veg. Scand. p. 321. 1849.  
*Fomes fomentarius* (L.) Gill. Champ. Fr. 1: 686. 1878.  
*Polyporus fomentarius* var. *pomaceus* Berk. & Br. Ann. Nat. Hist. V. 12: 373. 1883.  
*Fomes fomentarius* (L.) Fries, Sacc. Syll. Fung. 6: 179-180. 1888.  
*Ochroporus fomentarius* (L.) Schroeter in Cohn, Krypt. Fl. Schlesien 3 (1): 486. 1889.  
*Elfvíngia fomentaria* (L.) Murrill, Bull. Torrey Club 30: 298. 1903.  
*Elfvíngiella fomentaria* (L.) Murrill, Northern Polypores, Pub. by Author, New York, 64 p. 1914.

In addition to the above named species which are generally accepted as synonyms, Lloyd<sup>2</sup> would also add, among others, the following: *F. introstuppeus* Cooke, *F. marmoratus* Berk., *F. nigrescens* Klotzsch, *F. sclerodermeus* Lév., and *F. subfomentarius* Romell. While it would be surprising if certain of these species may not with justice be reduced to synonymy along with some other species that may have appeared in the literature, the writers feel it inadvisable to commit themselves on this point until it has been possible to study type specimens.

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<sup>2</sup> Lloyd, G. C. Synopsis of the genus *Fomes*. Myc. Writ. 4: 211-288. 1915.



## AN OVERWINTERING PYCNIDIAL STAGE OF *CICINNOBOLUS*<sup>1</sup>

C. E. YARWOOD

(WITH 1 FIGURE)

The parasitic development of *Cicinnobolus Cesatii* de Bary (syn. *Ampelomyces quisqualis* Cesati) on powdery mildews has been frequently recorded from many regions, and has been well described by Emmons.<sup>2</sup> Emmons described the entry of *Cicinnobolus* mycelium into sunflower leaves from the parasitized mildew *Erysiphe Cichoracearum* DC. and suggested that a perithecial stage of *Cicinnobolus* was formed in the sunflower leaf, but no adequate description of any overwintering stage has been found by the writer.

On October 15, 1931, at Lafayette, Indiana, the writer placed living clover leaves inoculated October 2 with *Erysiphe Polygoni* DC, and on October 4 with a pure culture of *Cicinnobolus* isolated from clover mildew, in a cheesecloth bag on open ground outdoors. On April 25, 1932, these overwintered leaves were examined. In addition to the old light brown mostly empty pycnidia of *Cicinnobolus* which had formed in the mildew mycelium and conidio-phores during the parasitic existence of *Cicinnobolus* the previous season, there were numerous dark brown pycnidia imbedded in the dead leaf tissues. Of 38 single spore isolations of the mature conidia within 2 of these pycnidia, 25 grew and yielded pure cultures of *Cicinnobolus*, typical of cultures isolated direct from the parasitic stage of *Cicinnobolus*. Cultures from the overwintered leaves were parasitic on living clover mildew.

Typical cultures of *Cicinnobolus* were also reisolated from pycnidia formed in mildewed clover leaves inoculated with *Cicinnobolus* and overwintered at Madison, Wisconsin, in the winter of

<sup>1</sup> The assistance of nontechnical employees of the Works Progress Administration is acknowledged.

<sup>2</sup> Emmons, C. W. *Cicinnobolus Cesatii*, a study in host-parasite relationships. Bull. Torrey Club 57: 421-441. 1930.

1932-33. At Berkeley, California, the saprophytic stage of *Cicinnobolus* was formed by June 6, 1936, on clover leaves which had been inoculated with *Erysiphe* and *Cicinnobolus* on May 1 of the same year, showing that overwintering or the exposure to low temperature was not necessary for the formation of this saprophytic stage.

Similar pycnidia of the saprophytic stage were formed at Berkeley in cucumber leaves inoculated with *Erysiphe Cichor-*

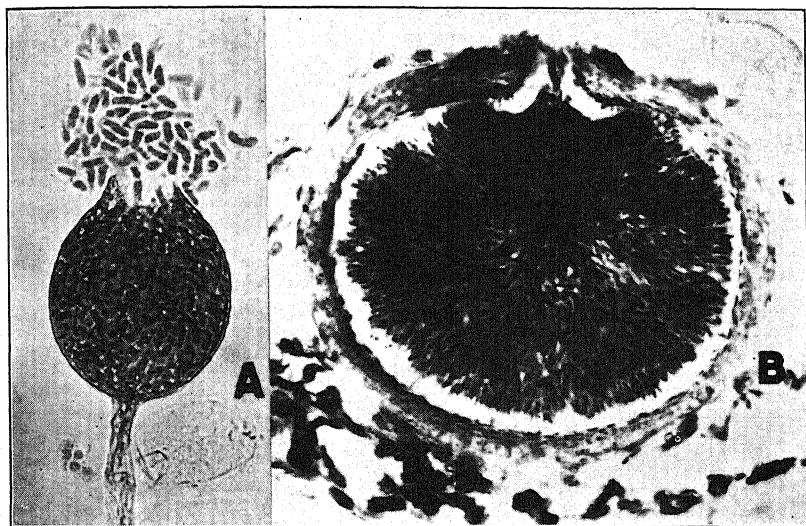


FIG. 1. Pycnidial forms of *Cicinnobolus Cesatii*, both  $\times 470$ . A, pycnidium formed parasitically within conidiophore of *Erysiphe Polygoni* on living clover leaf; an unparasitized conidium is shown at lower right; B, pycnidium formed saprophytically in dead overwintered clover leaf which had been inoculated, while living, with *Erysiphe Polygoni* and *Cicinnobolus Cesatii*.

*acearum* from cucumber and *Cicinnobolus Cesatii* from clover powdery mildew.

In the cultures at Madison and Berkeley perithecia of a *Pleospora* developed on the dead leaves containing the saprophytic stage of *Cicinnobolus*, but isolations gave only a *Macrosporium*, though no parasitic *Macrosporium* was known to be present on the inoculated leaves. The *Macrosporium* was somewhat similar to *Macrosporium sarcinaeforme* Cav. but formed fewer spores and

much more mycelium than typical cultures of *Macrosporium sarcinaeforme* isolated by the writer. This fungus is considered to be unrelated to *Cicinnobolus*.

Pycnidia of the parasitic and saprophytic stages of *Cicinnobolus Cesatii* are illustrated in figure 1. Parasitically formed pycnidia are light brown, thin walled,  $39-54 \times 18-29 \mu$ , discharging spores through an irregular opening at the apex, conidia biguttulate,  $3.5-8.4 \times 1.9-4.1 \mu$  (47 measured). Saprophytically formed pycnidia are dark brown, thick walled, spherical,  $79-140 \mu$  in diameter, discharging spores through a well formed ostiole, conidia biguttulate,  $6.0-11.1 \times 1.8-3.2 \mu$  (90 measured).

#### SUMMARY

A pycnidial stage of *Cicinnobolus Cesatii* has been found on dead clover and cucumber leaves, previously infected while living with powdery mildew and *Cicinnobolus*, and is apparently responsible for the overwintering of *Cicinnobolus* in nature.

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## NOTES ON FLORIDA FUNGI

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(WITH 3 FIGURES)

These notes are based on collections of fungi made by the author and others in various sections of Florida. Extension of the previously published host or geographical range forms the basis of interest in most instances. All of the species referred to are represented in the Herbarium of the Florida Agricultural Experiment Station and the various collections are indicated by the numbers at the end of each note.

### 1. DIDYMIUM COMPLANATUM (Batsch.) Rost.

Collected 24 July 1935 in Alachua County. Only the one collection has been made in Florida, but apparently it developed from a large plasmodium (*F* 18257).

### 2. PILOBOLUS UMBONATUS Buller.

This little *Pilobolus* developed abundantly for three seasons on rabbit dung incubated in moist chambers in the laboratory. Pellets collected during the winter in Alachua County, Florida, produced the fungus in almost every case. Pellets from three other widely separated counties (Gadsden, Brevard and Manatee) failed to develop the species. The photograph (FIG. 1) was taken 18 February 1935 and a description drawn up but withheld from publication at that time, thinking that another season's collecting might extend the range. The description corresponds to that published by Dr. Buller in Volume VI of "Researches on Fungi" in every point except the substratum (*F* 18258)

### 3. ASCOBOLUS VIRIDULUS Phill. & Plow.

This little discomycete has appeared on numerous occasions on the rabbit dung incubated for *Pilobolus*. After about a week in the moist chamber, the small, greenish-yellow cups appear, soon darkening with the ripening of the spores. They promptly be-

come pale again, when the lid of the moist chamber is raised and all the ripe asci have discharged their spores. The measurements of the Florida material differ slightly from those given by Seaver in "The North American Cup-Fungi." Many spores have been found up to  $16\ \mu$  long and somewhat over  $8.5\ \mu$  wide. However,

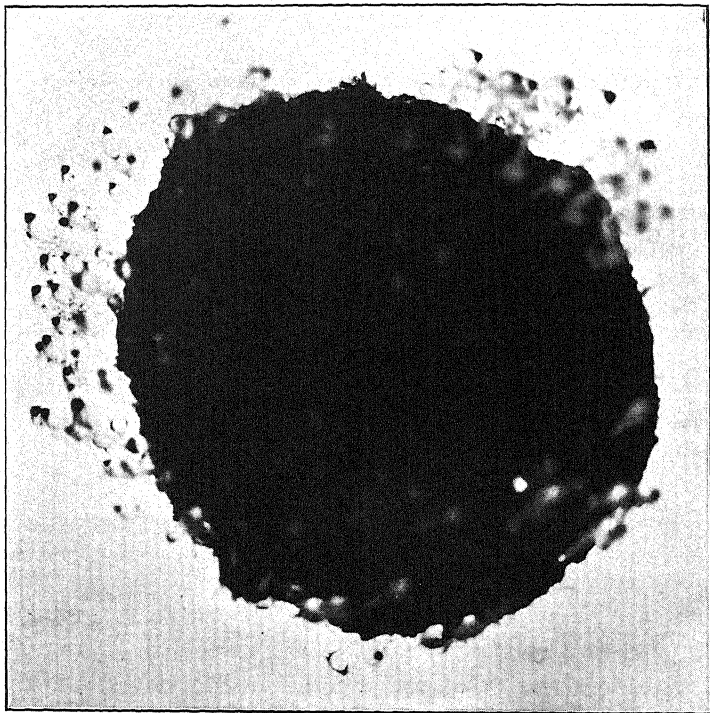


FIG. 1. *Pilobolus umbonatus* Buller.

the spore sculpturing is similar and there are no particular discrepancies in the other characters. One collection has been made under natural conditions on rabbit dung (*F* 3757).

#### 4. *PHILLIPSIA CHARDONIANA* Seaver.

This brilliant discomycete was collected in Alachua County on 28 July 1935 by Geo. F. Weber. This is the first record for the United States, although it has been collected previously in the West Indies (*F* 18256).

## 5. GYMNOSPORANGIUM TRANSFORMANS (Ellis) Kern.

While drying herbarium material collected in Liberty County in 1927 by L. H. Pammel and J. L. Seal, the telial stage of a rust was noted on one lot of *Chamaecyparis thyoides* (L.) B.S.P. Further examination of this material indicated that it was *Gymnosporangium transformans* (Ellis) Kern, a rust previously reported only from the northeastern states, Massachusetts to New Jersey. Since Florida was far out of this range, a specimen was sent to Dr. F. D. Kern, who kindly verified the identification.

Although the alternate host, *Aronia arbutifolia* (L.) Ellis, is common in this section of Florida, the aecial stage has not yet been found (*F* 17532, *F* 17533).

## 6. KUEHNEOLA MALVICOLA (Speg.) Arthur.

The uredinial stage of this rust has been collected several times on *Hibiscus syriacus* L. at Gainesville, Alachua County, and Jacksonville, Duval County (*F* 17085, *F* 5000, *F* 5001).

## 7. PHRAGMIDIUM SPECIOSUM (Fries) Cooke.

This rust has been collected frequently from 1932 to 1938 in Alachua County, Florida, on *Rosa palustris* L. growing on the margins of savannahs. The aecial stage is very conspicuous during the summer, but the telial stage forms inconspicuous felty masses around the twigs late in the fall. This is another common species that somehow has escaped being reported from the South (*F* 17206, *F* 18759).

## 8. PROSODIUM APPENDICULATUM (Winter) Arthur.

One collection of this rust was made at Miami in Dade County, Florida, on *Tecoma stans* (L.) Juss. on 2 February 1929. It has not been found previously in the United States but it is known from Cuba on this host. Only the uredinial stage has been found in Florida (*F* 17524).

## 9. PUCCINIA ANDROPOGONIS XANTHOXYLI (Peck) Arthur.

The aecial stage of this rust was collected on *Zanthoxylum Clava-Herculis* L. at Gainesville, Alachua County, Florida, on 28 April 1928 and 20 March 1938. There are no known previous records of the rust in Florida (*F* 4773, *F* 17197).

## 10. PUCCINIA COOPERIAE Long.

What appears to be this rust has been collected a number of times in Florida during the past two years on several species of *Zephyranthes*. It was described by Long<sup>1</sup> from specimens on *Cooperia* in central Texas and Arthur in his "Manual of Rusts" limits it to the same host and region. *Cooperia* is closely related botanically to *Zephyranthes*, but there are no native *Cooperias* known in Florida and but few grown in gardens. In one garden where *Cooperia* and *Zephyranthes* were both grown, only *Zephyranthes* was found infected. Nevertheless, the rust on *Zephyranthes* corresponds morphologically to the species described by Long.

As mentioned by Long for *Cooperia*, all stages of this rust may be present on the same leaf at the same time. Severe infections on the leaves are frequent and in one instance a peduncle (*Z. Treatiae*) was infected.

The teliospores present two interesting and striking characteristics in their attachment and markings. As figured by Long, the spores are frequently bent over so that they seem to be attached at the side. All angles between the normal vertical position and horizontal may be found in the same mount. The peculiar markings on the teliospores consist of several longitudinal ridges, sometimes interrupted and occasionally anastomosing. Their presence gives the spore an angular outline when viewed either from the side or end.

This is the first report of this rust in Florida and in addition to adding a new host genus for the fungus, it greatly extends the geographical range. Two other rusts, both *Aecidium* spp. have been found on *Zephyranthes* sp. in Mexico, but they are quite distinct from *P. Cooperiae*.

Aecio-, uredio- and teliospores from *Z. Treatiae* sown on *Cooperia* (*C. pedunculata* Herb., *C. Drummondii* Herb. and *C. Traubii*) have produced no infection; when sown on *Z. Treatiae*, infection resulted. As morphological characters are lacking, it seems undesirable to designate the rust on *Zephyranthes* as a new form until further inoculations have been made.

Florida collections have been made as follows:

<sup>1</sup> Long, W. H., Jr. Bull. Torrey Club 29: 110. 1902.

- On *Zephyranthes Atamasco* (L.) Herb., Jackson County (F 16860).
- On *Zephyranthes Treatiae* S. Wats., Alachua County (F 17514, 17511); Putnam Co. (F 16861).
- On *Zephyranthes Simpsonii* Chapm., Alachua County (F 17512); Volusia County (F 17513).
- On *Zephyranthes* n. sp. (*Z. insularum* Hume in litt.) Alachua County (F 17515).
- On *Zephyranthes* n. sp. (*Z. floridana* Hume in litt.) Polk County (F 17510).
- One collection has been made on *Zephyranthes Atamasco* at Durham, N. C., communicated by Dr. G. B. Cummins (F 17208).

#### 11. PUCCINIA POLYGONI-AMPHIBII TOVARIAE Arthur.

This form has been collected twice near Gainesville, Alachua County, on *Tovara virginiana* (L.) Adans. It has not been reported previously nearer than Louisiana and North Carolina. Only the uredo stage has been found in Florida (F 17534, F 17535, F 16976).

#### 12. PUCCINIA RAUNKAERII Ferd. & Winge.

Collected on *Rivinia humilis* L. in Brevard County on 25 July 1929 and in Alachua County, Florida, on 25 May 1933. It seems remarkable that a rust causing such conspicuous malformations on a common hammock plant should have escaped observation for so long. The wide distribution of the disease as shown by the divergence of the collections would indicate that the fungus is not a recent immigrant in Florida. Previously reported in the United States from Texas (F 17516, F 17519).

#### 13. RAVENELIA HUMPHREYANA P. Henn.

This rust was collected on *Poinciana pulcherrima* L. in Dade County on 28 March 1928 and again exactly one year later. Only the uredinial stage has been found. There do not seem to be any previous records from the United States, although it has been reported from Cuba, Jamaica, Mexico and Guatemala (F 17525, F 17526, F 17527).



14. *RAVENELIA SILIQUAE* Long.

Specimens of this rust were collected in Alachua County, Florida, 24 March 1934 on the green fruits of *Vachellia farnesiana* (L.) W. & A. Only one plant in a nursery bore infected fruits. Fruit produced in 1935 remained healthy. In the United States this has been reported previously only from southern Texas (F 18255).

15. *UREDIO CUMULA* Arthur.

Specimens of this rust were collected in Alachua County on *Buchnera floridana* Gandoger on 10 May 1933 by W. B. Tisdale. Only two diseased plants were found but both were heavily infected. This rust was reported by Arthur in North American Flora as known only from the type locality in Cuba on *Buchnera elongata* Sw., a species very closely related to the Florida host (F 17522).

16. *UROMYCES AGNATUS* Arthur.

This rust is common on tread-softly (*Bivonea stimulosa* (Michx.) Raf.) in Florida. The literature shows no record of any pycnial or aecial stage. During May 1938 abundant material of these two stages was collected near Gainesville. Pycnia and aecia are most common on effused galls near the ground line or just below it and are not apparent until the plant is dug up. The galls frequently involve hypertrophied lateral shoots 1 cm. or less long. Occasionally small ones, 5 mm. or less in diameter, occur at the base of petioles, base of leaf blade, on either surface of the leaf blade; more rarely large areas 2-3 cm. long on the underside of the midrib and following out lateral veins a short distance. Various parts of the inflorescence may be involved (FIG. 2, 3). All affected parts bearing aecia are bright yellow.

Most of the plants with aecia also showed uredinia on the underside of the lower leaves at the same time.

Pycnia scattered among the aecia. Aecia amphigenous on bright yellow hypertrophied areas, cupulate, aeciospores globoid  $20-23\ \mu$   $\times$   $22-26\ \mu$ ; wall colorless  $1-2\ \mu$  thick, shallowly verrucose. Collected 10 and 11 May 1938 near Arredonda, Alachua County, Florida (F 16718, F 16719, F 16720).

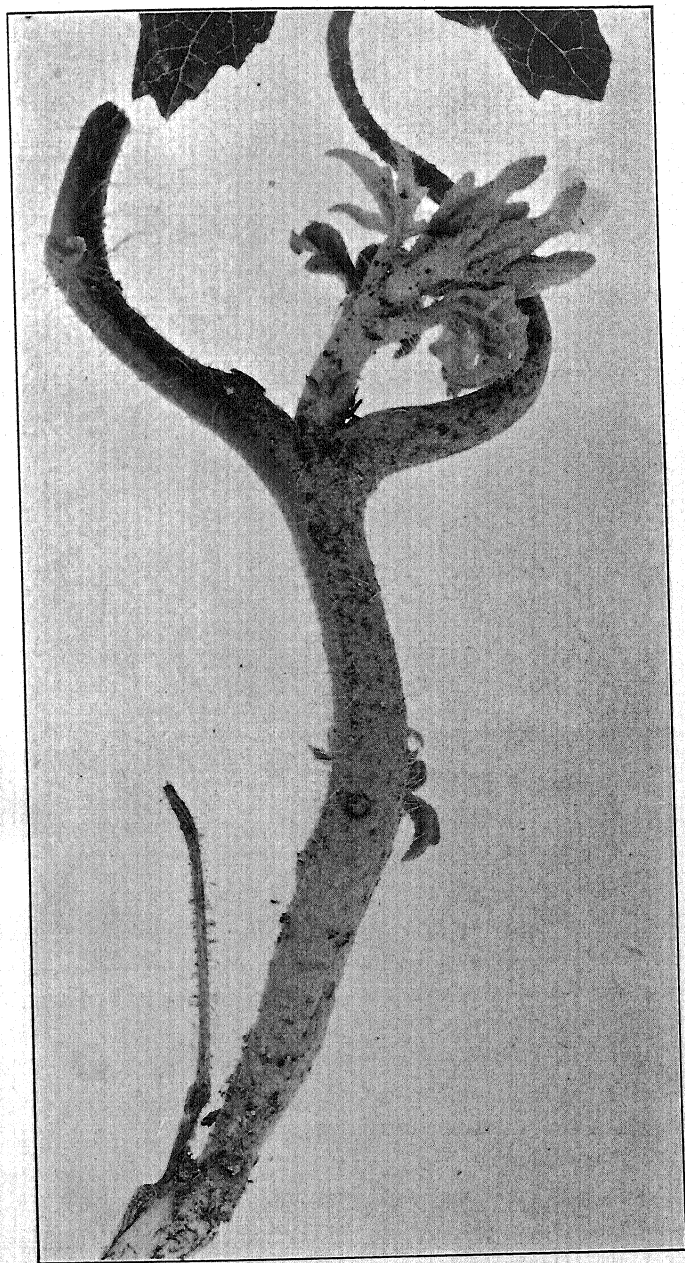


FIG. 2. Pycnia and aecia of *Uromyces agnatus* Arthur on stem and inflorescence of *Bivonea*.



FIG. 3. *Uromyces agnatus* Arthur. Aecia on galls on various organs of *Bivonea*. Lower leaf shows uredia on lower surface.

17. *UROMYCES CESTRI* (Mont.) Leo.

One collection was made on *Cestrum diurnum* L. 18 May 1936 also in Broward County, on 25 April 1934. This is the first record of this rust on the mainland of North America. Previous collections have been made in the West Indies, Central and South America on various species of *Cestrum*. On *C. diurnum* it has been reported only from Cuba (*F* 17517, *F* 16740).

## 18. UROMYCES INDIGOFEAE D. &amp; H.

Typical material was collected in Alachua County, Florida, on *Indigofera tinctoria* L. on 28 February 1929 and again on 17 November 1935 on *I. suffruticosa* Mill. There does not seem to be any previous record of this rust in the United States (*F* 17529, *F* 17530, *F* 16764).

## 19. UROMYCES PUNCTATUS Schroet.

One collection of this rust was made on *Phaca intonsa* (Sheldon) Rydb. in Alachua County, Florida, on 13 June 1930 and again on 18 March 1935. This collection adds a new host for the fungus and extends its range to the Atlantic Coast (*F* 16795, *F* 16796).

## 20. UROMYCES SPARGANII C. &amp; P.

This rust was collected in Sugarfoot Prairie near Gainesville, Alachua County, Florida, on *Sparganium eurycarpum* Engelm. on 10 June 1932. This is a northern species not previously reported south of Ohio (*F* 17518).

## 21. POLYPORUS AMPLECTENS (Murrill) Sacc. &amp; Trott.

This magnificent little polypore was described by Murrill from specimens on *Asimina* in Georgia. It seems to resemble closely *P. fruticum* Berk & Curt. and Lloyd so referred all his specimens. *P. fruticum*, it has been reported, was described from *Nerium* branches but according to Lloyd *Asimina* was the original host. However, the plant has never been found on *Nerium* in Florida, although infected pawpaw bushes have been found within ten feet of oleanders.

A recent memorandum from Miss E. M. Wakefield at Kew to Dr. W. A. Murrill contains the following information on this point: "Of the three Cuban specimens named by Berkeley *Polyporus fruticum*, only two, nos. 161 and 442, show any trace of the host plant. These appear to be the same, though no. 161 is very fragmentary. No. 442 shows three leaves, elongated obovate in shape, blunt at the apex, coriaceous in texture with rather strongly marked, numerous, parallel lateral nerves. Mr. Sandwith has examined this specimen but is unable to suggest what the plant may be. It is however not *Asimina*."

"The Cuban specimens of the fungus are probably all alike and appear to be the same species as *Inonotus amplexans* Murr. On the same mount as no. 160, however, a Brisbane specimen was stuck by Berkeley. This Brisbane specimen is in my opinion different, and is *Polyporus Weberianus* Henn. It is probable that it is this specimen which has given rise to erroneous ideas as to the identity of *Polyporus fruticum*."

Whatever the status of the species, it is not so rare as indicated by Lloyd and Murrill. In some areas of Florida hardly a pawpaw bush can be found that does not bear one or more of the brown sporophores encircling the branches.

Florida collections include the following hosts:

On *Asimina parviflora* (Michx.) Duna—Orange Co. (*F* 15520, *F* 15517, *F* 15518), Levy Co. (*F* 15516), Alachua Co. (*F* 8776).

On *Pityothamnus angustifolius* (A. Gray) Small—Alachua Co. (*F* 8775, *F* 8756, *F* 8777).

On *P. incanus* (Bartr.) Small (unreported host)—Orange Co. (*F* 15525, *F* 15523), Alachua Co. (*F* 8781).

On *P. obovatus* (Willd.) Small (unreported host)—St. Johns Co. (*F* 15524).

On *P. pygmaeus* (Bartr.) Small—Orange Co. (*F* 15522, *F* 15519, *F* 15521).

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## THE MORPHOLOGY OF PHYSALACRIA INFLATA

J. M. McGUIRE

(WITH 14 FIGURES)

The genus *Physalacria* was established by Peck in 1882 when he showed that the fungus described by Fries as *Mitrula inflata* and later by Cooke as *Spathularia inflata* was actually a Basidiomycete (6). In an excellent description, Peck stated that the surface of the bladder-like head is everywhere covered by the hymenium; and on this basis he included the genus in the family Clavariaceae, where it is generally placed at the present time. He also mentioned that he could find but two sterigmata on the basidia.

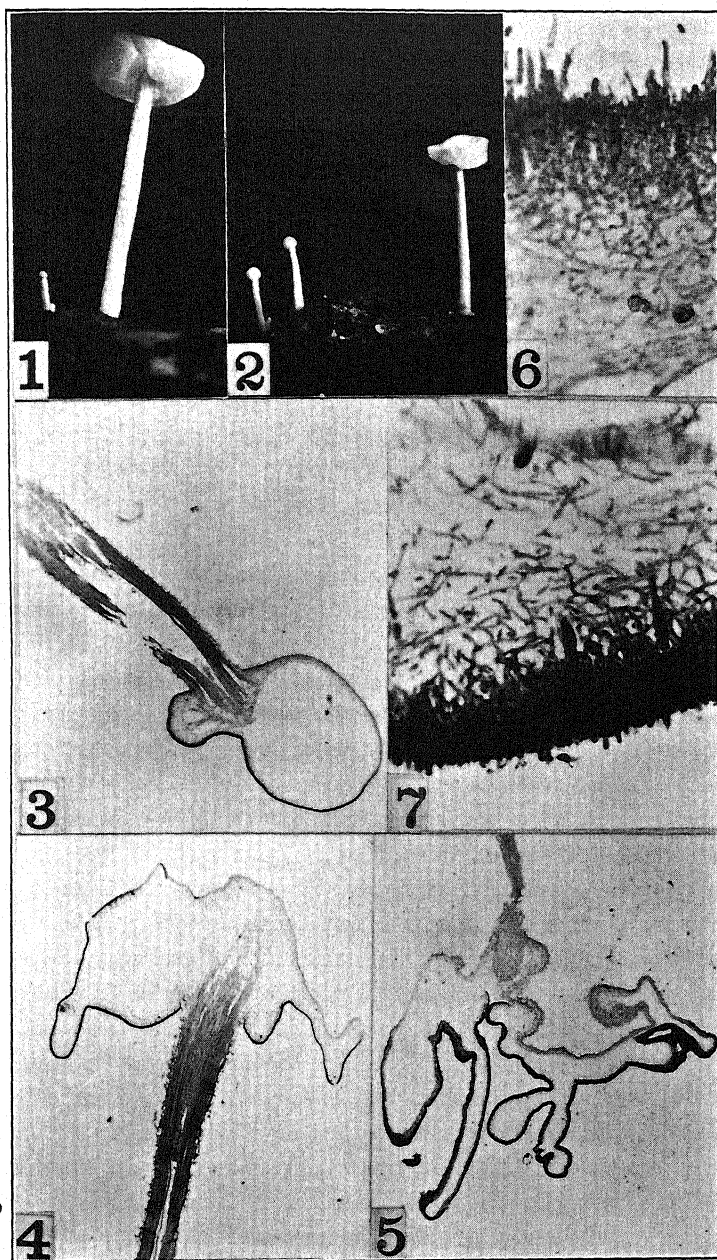
Krieger (3), examining fresh specimens, claims to have found several characters at variance with Peck's description. He asserts that the cap is differentiated into distinct upper and lower surfaces, and that the hymenium is borne only on the latter. The upper surface, he finds, shows a looser cell arrangement, with hair-like and encrusted cells scattered about the transition from hymenial to sterile surface. Moreover, the hymenial surface is described as typically thrown into gill-like folds, each ending at the stipe in a decurrent tooth, much as do decurrent gills. The specimens studied by Krieger apparently all grew erect and the hymenium was in the same relative position as it is in a stalked agaric. Because of this restriction of the hymenium to the lower surface and the resemblance of the folds on the lower surface to gills, Krieger proposed to remove the fungus from the Clavariaceae to the Agaricaceae, renaming it *Eoagaricus inflatus*. He states (3, 4) that the stipe is always laterally attached, so that the radiately folded, gill-like hymenium, borne on one side of the stipe, faces downward in the young basidiocarp. As maturity is reached the bladder-like cap is erected by contraction of the tissues of the stipe on one side. The figure illustrating this (4, p. 192) is contradictory, however, in that the folds shown are not radiate and do not appear to terminate at the stipe in decurrent teeth.

Little has been done to clear up the conflict between Peck's original description and Krieger's findings, possibly because the fungus is comparatively rare. Lloyd (5), who collected *Physalacria inflata* several times and received collections also from Burt, believed the hymenium to be amphigenous as described by Peck. Bresadola, to whom Lloyd sent specimens, reported that the basidia bear four sterigmata. Killermann (2), after reading Krieger's paper (3), examined Berlin herbarium material and found the hymenium on all sides. As Coker (1) has remarked, the change of generic name suggested by Krieger is prohibited by the rules of nomenclature.

The present attempt to clarify the morphology of *Physalacria inflata* was made possible by an excellent collection of this fungus on a dead stick in low, wet woods along the Blue River, DeWitt, Nebraska, on June 12, 1938. The stick bore a clump of long-stalked basidiocarps, the stipes confluent at the base. It was brought to Iowa City and placed in a favorable spot in the woods, where two crops of basidiocarps were produced during the summer. On September 12, 1938, the stick was brought into the laboratory and placed in a moist chamber, where several more fructifications have developed and produced spores. Some were fixed in Nawaschin's solution or formalin-acetic-alcohol, imbedded in paraffin, sectioned, and stained in Haidenhain's iron-alum haematoxylin. Others were sectioned freehand or crushed out and examined in weak KOH-phloxine mounts. The rest were dried and placed in the mycological herbarium of the University of Iowa.

Microscopic examination of phloxine-stained fresh mounts disclosed clearly that the hymenium bears typical clavate, four-spored homobasidiomycetous basidia (FIGS. 12, 13). Sections stained in haematoxylin show just as clearly that the surface of the cap is, as Krieger (3) states, differentiated into distinct upper and lower regions, the hymenium being restricted to the lower half. But contrary to Krieger's observations, I find no consistent appearance of gill-like folds radiating from the stipe on the lower surface of the cap. What he apparently did not notice is that the stalks of *Physalacria inflata* do not always stand erect. In fact, very few of the large number of basidiocarps observed in the course of this study grew erect. Many developed directly downward; others





FIGS. 1-7. *Physalacria inflata*.

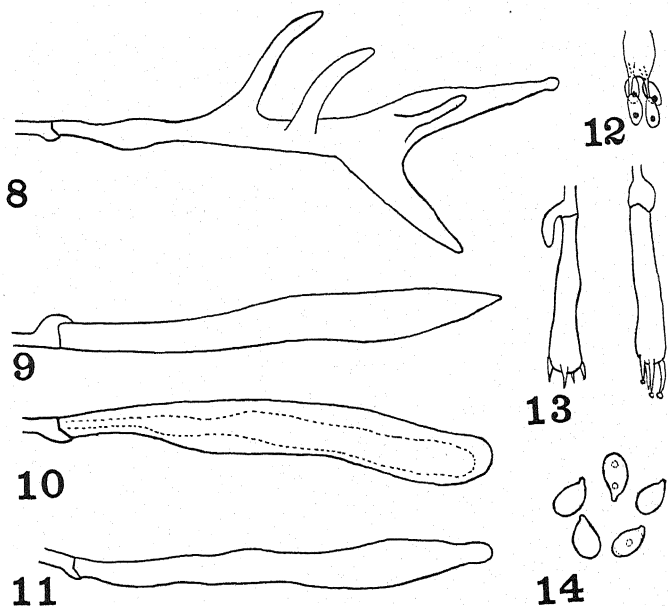


grew out horizontally or obliquely from the stick to which they were attached. Consequently, the hymenium, which is always borne on the lower portion of the bladder, does not always occur, indeed seldom occurs, in the area immediately surrounding the attachment of the stipe to the pileus, as do the hymenium-bearing gills of the Agaricaceae. Sections of basidiocarps show that whether they grew erect, downward, horizontally, or obliquely, the hymenium invariably occupies the portion of the head which is actually turned downward (FIGS. 3-5). No constant relationship can be seen between the position of the hymenium and the stipe, lobes, folds, or any other irregularities in the surface which might be considered gill-like. In most cases the sterile and the hymenial surfaces were unequal, the latter generally appearing more broadly expanded, rounded, and often invaginated or irregularly lobed, while the upper surface was usually quite smooth and more or less flattened.

New fructifications arise as straight, cylindrical white stalks. Early in the growth of the stalk, a tiny knob appears and gradually expands as the stipe continues to elongate (FIGS. 1, 2). The bladder continues to enlarge for some time after the stipe ceases to elongate, the entire growth period extending over one to two weeks. In all cases observed, the head is nearly globose and centrally attached at the start. It soon takes on the aspect of an inflated bladder, and as it nears maturity may partially collapse. The appearance of lateral attachment of the stipe to the bladder, which Krieger says is universal, was noticed frequently in the later stages of growth. It did not occur in any consistent manner, however, and rather than comprising a fundamental character seems to vary with the position of the basidiocarp and the direction of the light source. The caps seem quite consistently to expand most on the side turned away from the light, although the light at the time of all observations was indirect and diffused. The surfaces of the inflated heads usually remained quite smooth until maturity, when drying resulted in an increasingly wrinkled and lobed appearance. No lobes or folds which by their structure or location might be considered homologous with gills were observed.

Two kinds of cystidia occur on the surface of the head, the one thick, clavate, generally somewhat constricted just back of the broadly rounded tip, usually taking a deep stain with iron-alum

haematoxylin, originating deep within the context and commonly protruding  $5\text{--}15\ \mu$  beyond the surface (FIGS. 7, 10, 11), and the other generally more slender, fusoid, often branched, taking almost no iron-alum haematoxylin stain, arising nearer the surface and protruding  $20\text{--}40\ \mu$  (FIGS. 6, 8, 9). Both types of cystidia are heavily incrustated. The incrustation is dissolved in 3 per cent KOH mounts, but is little affected by the killing solutions, alcohol, and xylol used in making permanent mounts. Contrary to Krie-



FIGS. 8-14. *Physalacria inflata*.

ger's observation of hair-like and incrustated cystidia scattered about the transition zone between sterile and hymenial portions of the cap, I find cystidia scattered over the entire surface. The two surfaces differ markedly, however, in the types and distribution of cystidia which they bear. The sterile surface bears in great numbers both the thick clavate cystidia and the more slender fusoid, frequently branched cystidia, the latter in much greater numbers (FIG. 6). The cystidia on the hymenial surface are not only much less numerous, but are almost exclusively of the dark-staining clavate type (FIG. 7).

It is my opinion, based on the fact that the hymenium is unilateral and inferior, that *Physalacria inflata* does not belong in the family Clavariaceae, at least as that family is now defined. On the other hand, since gill-like folds, even when present, bear no relationship to the hymenium, and because of other obvious dissimilarities between the inflated, membranaceous basidiocarp of *Physalacria* and those of the gill fungi, I see no justification for placing this fungus in the Agaricaceae. An alternative, since the hymenial elements are clearly those of a homobasidiomycete, might be to include this fungus in the Thelephoraceae, which is characterized by an inferior hymenium.

This study was suggested by Professor G. W. Martin and carried out in the mycological laboratories of the State University of Iowa.

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#### EXPLANATION OF FIGURES

FIG. 1, three basidiocarps, one mature, two young,  $\times 3$ ; 2, group of basidiocarps,  $\times 2$ ; 3, longitudinal section of basidiocarp in position as developed, showing densely stained hymenial surface below and paler sterile surface above,  $\times 12$ ; 4, section of erect basidiocarp, break in wall marking actual end of hymenium on left side,  $\times 12$ ; 5, section of basidiocarp which grew downward, wrinkled because over-mature when fixed,  $\times 12$ ; 6, section of sterile surface,  $\times 300$ ; 7, section of hymenium,  $\times 300$ .

FIGS. 8-14 drawn with the aid of camera lucida and reduced in reproduction to a magnification of approximately  $\times 1200$ . FIG. 8, branched cystidium from sterile surface; 9-11, fusiform and clavate cystidia, incrustation not shown; 12-13, basidia; 14, spores.

## THE ENTOMOGENOUS CHYTRID MYROPHAGUS THAXTER<sup>1</sup>

F. K. SPARROW, JR.

(WITH 8 FIGURES)

Some years ago the late Prof. Roland Thaxter showed me herbarium material and camera lucida sketches of a peculiar chytridiaceous fungus found by him at Kittery Pt., Me., on dipterous pupae lying in leaf mould. He urged that further search be made for the organism in order to obtain information on certain unknown phases of its life history, as it appeared to represent the type of a new genus. Having been uniformly unsuccessful in this quest I shall record here what is already known about it with the hope that others interested in entomogenous fungi will fill in the lacunae which now exist in its life cycle. I am indebted to Dr. D. H. Linder, Curator of the Farlow Herbarium, for lending me the material and the camera lucida sketches made by Thaxter from which, along with certain notes made in 1927, the following account has been derived.

The only description of this fungus known to me is that of Wize (1) who gave a brief account of the formation of the resting spore and a taxonomic diagnosis under the name *Olpidiopsis ucrainica* Wize. His material was found in larvae of *Cleoni*, *Anisoplia*, in The Ukraine. The organism was described as being fairly rare in its occurrence in that region. Wize noted that the fungus reduced the entire interior of the pupa to an orange colored powdery mass. The earliest stage found was a somewhat spherical cell 35  $\mu$  in diameter with granular contents. Later the central region became strongly refractive and golden. Eventually the developing contents became transformed into a double walled resting body which nearly filled the containing structure. This containing

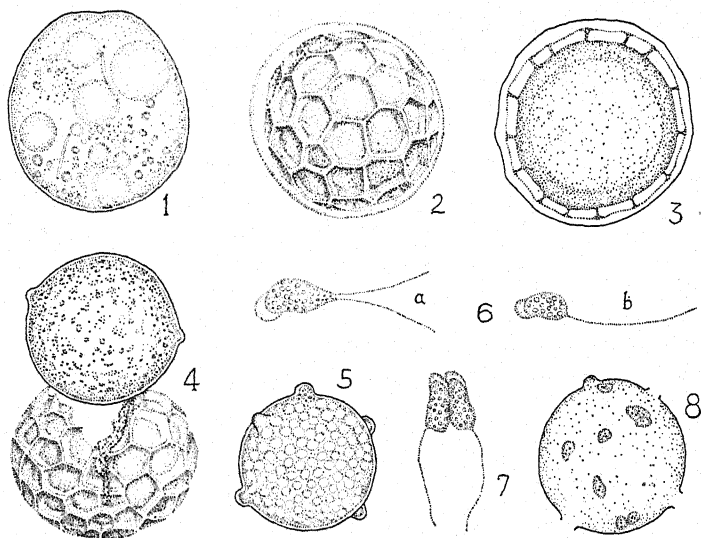
<sup>1</sup> Paper Number 684 from the Botany Department, University of Michigan. The preparation of this paper was assisted by a grant from the Horace H. Rackham School of Graduate Studies.

wall then disappeared leaving free in the cavity of the insect a spherical, golden spore, 20–30  $\mu$  in diameter. The outer wall of the spore was raised in a series of reticulations, and in its content were one (15–25  $\mu$  in diameter) or many ( $5 \times 3 \mu$ ) deeply colored globules. No information was given on the vegetative stage other than on the aforementioned sac-like structure within which the resting body was formed. The further fate of this resting spore was not known.

Thaxter's material is similar in appearance to that of Wize. The method of infection and early stages of development are not known. When freshly collected, the contents of diseased pupae are almost completely disintegrated and replaced by a reddish mass of fungous material which as it dries becomes reddish-orange. An examination of this pulverized complex shows it to be made up largely of thousands of beautifully reticulated resting spores (FIGS. 2, 3) each of which lies within a thin-walled sac. These sacs (FIG. 1) are ellipsoidal or very rarely spherical and vary from 55–71  $\mu \times 49$ –66  $\mu$ ; the resting spores are spherical and 46  $\mu$  to 72  $\mu$  in diameter. There is no positive evidence of any filamentous vegetative system or of any companion cells. Occasionally, thread-like structures are found attached to the sacs, but these are septate and can be traced to fruiting Imperfecti which have also invaded the pupa. The vast majority show no hyphal or rhizoidal connections of any sort. It should be pointed out however that Thaxter's sketches show several zoöspores which upon germination have formed definite tubular structures. Whether these represent penetration tubes or the beginnings of a filamentous vegetative stage can only be decided by new observations on living, young material. Thus it can be seen that, while the American material is somewhat larger, in all probability Wize and Thaxter were dealing with the same organism.

Thaxter secured germination of the resting spores. This occurred after they had been kept outside all winter until April in moist Sphagnum and earth. Such spores when placed in hanging drop cultures in distilled water cracked open and there was extruded a spherical vesicular body 50–86  $\mu$  in diameter (FIG. 4). Discharge was a continuous process and took about two hours for

completion. The new structure thus formed was nearly or completely free from the wall of resting spore (FIG. 4). The protoplasm of the vesicle was vacuolate and the wall slightly thickened. In the course of the maturation of this structure which may be considered the sporangium, the protoplasm passed through a strongly vacuolate stage, the vacuoles becoming areolate; circlets of droplets then appeared and formed a well defined reticulum. During maturation up to 5 or more prominent papillae were formed on the surface of the wall (FIG. 5). Two to three hours after the emission of the vesicle its contents had become cleaved



FIGS. 1-8. *Myrophagus ucrainicus*.

into many uniform segments—the zoöspores. These subsequently emerged through slightly elevated pores formed upon the deliquescence of the previously mentioned papillae (FIG. 8).

The zoöspores (FIG. 6b), which are more or less irregularly ovoid or ellipsoidal, are often attenuated at the ciliated end and terminate anteriorly in a broad lobobodium. The plasma is finely granular at the extremities and coarsely granular in the midregion. It is not clear from the notes whether or not the granulations mentioned are refractive. From the figures the body of the spore always appears slightly gibbose. One or occasionally two (FIG. 6a)

or three cilia about twice the length of the body project from the rear. The notes indicate, however, that one cilium is considered the typical number. The period of motility in hanging drops varies from 2-3, up to 5 hours, after which the zoöspores become amoeboid and encyst. Upon germination each zoöspore produces a somewhat irregular, unbranched tube from its spherical, uni-guttulate body. No other stages of development are given. One sketch shows two zoöspores fused laterally (FIG. 7) but their further fate is not recorded.

From even the somewhat fragmentary observations of Wize and Thaxter it is evident for several reasons that the fungus cannot be placed in *Olpidiopsis*. In this genus the resting stage arises as the result of a sexual process involving the fusion of the contents of a receptive cell and one or more companion cells. The resting body resulting from this fusion does not ordinarily lie loosely within the receptive cell, but rather the whole structure is transformed into the resting spore. There is therefore, no surrounding wall distinct from that of the resting spore itself. Further, in *O. Schenkiana*, where germination of the resting structure has been observed, the spore itself produces a tube and functions as a sporangium, no external vesicular structure being formed as in the present fungus. Lastly, in *Olpidiopsis* the zoöspores are biciliate and have the cilia laterally, not posteriorly, attached.

In *Woronina glomerata*, Zopf (2), a parasite of uncertain relationships, found in *Vaucheria*, reticulate resting spores similar to those of the present fungus are formed. However, upon their germination, the majority of the zoöspores are produced within the resting cell and are discharged through a tube to the outside of the alga. The present fungus also resembles to some degree a species of *Olpidium*, but wherever germination of the resting spores has been observed in this genus, the zoöspores are formed within the resting body and discharged through a tube. Perhaps the closest resemblance in resting spore germination is to be found in that of the genus *Micromyces* and of those species of *Synchytrium* ordinarily placed in the subgenus *Pycnochytrium*. Here, the resting body acts as a prosperangium, the protoplasm being discharged into an exterior vesicle where a sorus of sporangia is formed. Thaxter's fungus differs from these genera, however, in

that its "vesicle" becomes transformed into a single, multiporous sporangium.

Since the unique characters of Wize and Thaxter's fungus distinguish it not only from *Olpidiopsis* but also from other related forms, it is placed in a new genus, as proposed by Thaxter and given the name suggested by him.

**Myrophagus** Thaxter, gen. nov.

Vegetative thallus endobiotic, so far as known, an ellipsoidal or spherical walled body which at maturity forms endogenously a single resting spore; resting spore upon germination cracking open and extruding a vesicular structure which becomes a sporangium; zoöspores posteriorly uniciliate, formed within the sporangium, escaping through one or more pores; method of infection and early development unknown.

Visibilis thallus ellipsoidal vel globosus, maturitate perdurantem sporam singulam formans; spora perduranti fractione sporangium vesiculare liberum formante; zoosporis postice uniciliolatis endogenis per poros 1-5 liberatis. Infectionis modus et status juvenalis ignoti.<sup>2</sup>

**M. ucrainicus** (Wize) Sparrow, comb. nov.

Syn. *Olpidiopsis ucrainica* Wize in, Akademija Umiejetności Krakow (Bull. Intern. Cl. Sci. Math. nat.) 1904: 715. fig. 1, a-g. 1905.

Resting spore spherical, 20-72  $\mu$  in diameter, borne singly and loosely in an ellipsoidal (55-71  $\mu \times$  49-66  $\mu$ ) or spherical (35  $\mu$  in diameter) sac-like structure, the outer wall golden, raised in a series of polygonal reticulations, the inner wall smooth; sporangium formed at germination 50-86  $\mu$  in diameter; zoöspores ellipsoidal or ovoid, somewhat gibbose and attenuated posteriorly, contents with numerous granules, cilium 2-3 times length of body, emerging through up to 5 slightly elevated pores.

In larvae of *Cleoni*, *Anisoplia*, The Ukraine (U. S. S. R.), Wize; dipterous pupae, Thaxter, Kittery Pt., Maine, collected Sept. 18, 1902.

Material examined: Thaxter no. 994. Farlow Herbarium.

<sup>2</sup>In am indebted to Prof. H. H. Bartlett for the Latin diagnosis of *Myrophagus*.



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## EXPLANATION OF FIGURES

FIGS. 1-8. *Myrophagus ucrainicus*. FIGS. 1-3, from herbarium material,  $\times 450$ ; FIGS. 4-8, from Thaxter's camera lucida sketches.

FIG. 1, ellipsoidal body within which a resting spore will be formed; 2, surface view of resting spore within its sac; 3, optical section of same; 4, sporangium which has emerged from germinated resting spore; two papillae visible; 5, sporangium free from resting spore, showing 5 visible papillae; 6a, biciliate zoospore; 6b, uniciliate, typical zoospore (these were drawn at the same magnification); 7, two zoöspores apparently conjugating, magnification not given; 8, nearly empty sporangium showing exit pores.

Figures inked in by Richard Higgins.

## MYCELIAL HABIT IN SOME SPECIES OF TAPHRINA

A. J. MIX

(WITH 2 FIGURES)

The genus *Taphrina* is in general characterized by intercellular or subcuticular mycelium. Many species, like *Taphrina deformans*, form intercellular vegetative mycelium and a subcuticular ascogenous layer. Other species, as *T. Betulae*, *T. carnea*, *T. caerulescens*, etc., are reported as having mycelium that is subcuticular only, never intercellular. Sadebeck (5) makes this difference in mycelial habit one of the distinguishing characters between his genera *Exoascus* and *Taphrina*.

Two species have been described which depart from both of the above types: *Taphrina laurencia* Giesenhag., and *T. maculans* Butl. The former, which occurs on *Pteris quadriaurita* Retz. is described by Giesenhagen (2) as forming mycelium and ascogenous cells in the outer portion of an epidermal cell of the host, being separated from the host-protoplasm by a thin cellulose wall. It is implied in Giesenhagen's account that the fungus gains entrance to the interior of an epidermal cell and becomes subsequently walled off.

According to Butler (1) the mycelium of *T. maculans* grows at first beneath the cuticle, lying for the most part above the radial walls of the epidermal cells. Flat bands of hyphae pass downward in these radial walls "which are split to give them passage." (Butler loc. cit.) Development of these hyphae may be so great that the lumina of the host-cells become almost occluded by distention of the lateral walls. The fungus also develops in the outer tangential walls of the epidermal cells, and growth of the mycelium may depress the inner layer of the wall almost to the obliteration of the cell cavity beneath.

The writer's interest in this type of mycelial habit among species of *Taphrina* was aroused by a study of *Taphrina californica*

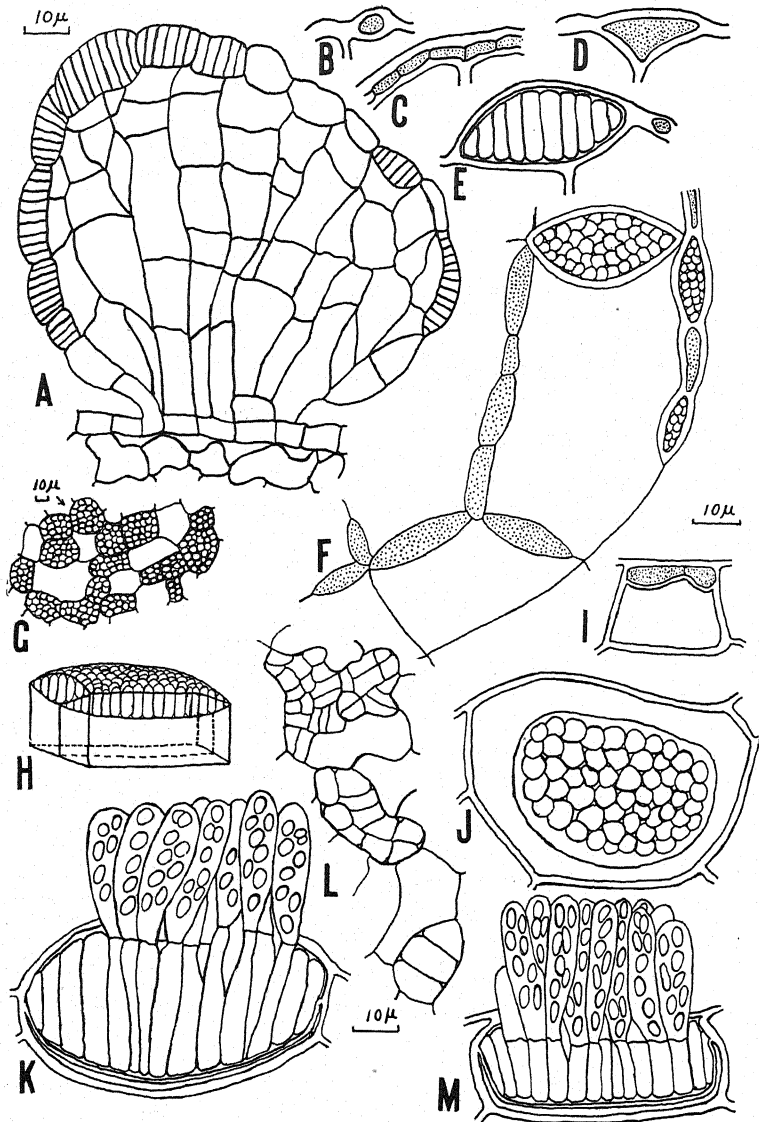


FIG. 1. *A*, young gall caused by *T. californica*, with ascogenous cells of the fungus in the outer cells; *B*, *C*, *D*, mycelium of *T. californica* growing within epidermal walls; *E*, ascogenous cells of the same in a wall-locule; *F*, surface view of a portion of a gall, showing growth of mycelium above radial walls of host cells; *G*, surface appearance (at lower magnification) of gall with ascogenous cells; *H*, diagram to show development of asco-

Mix (4), which causes galls on the leaves of *Dryopteris arguta* (Kaulf.) Wats. This study led to examination of certain other fern-inhabiting species and to re-examination of *T. laurencia* and of *T. maculans*. The results are here presented.

#### TAPHRINA CALIFORNICA

The fungus was collected at Lake Phoenix, Marin County, California, September 4, 1930, by H. E. Parks and distributed (California Fungi no. 403) under the name *Taphrina filicina* Rostr. This material shows ascogenous cells but no asci. Ascus-bearing galls were found in material especially collected for the writer by Dr. Lee Bonar, November 28, 1937. Early stages of the galls were found in a collection made by Victor Duran, August 21, 1930.

The first stages of gall-development were not found, as the youngest galls examined consisted of several cells. It is clear, however, that the gall is epidermal in origin, arising by repeated tangential divisions of cells of the epidermis (FIG. 1, A). The new cells thus produced become greatly enlarged, especially in a radial direction, have thin walls and are devoid of chlorophyll. Each cell on the surface of the gall was originally the outer portion of an epidermal cell of the leaf. For convenience these may be called epidermal cells of the gall. They are covered by a thin cuticle, approximately as thick as that on the healthy part of the leaf. After a gall has become much enlarged, some hyperplasia may occur in the cells of the mesophyll, but this is a secondary event; and does not alter the fact of the epidermal origin of the gall.

In young galls early stages of mycelial growth may usually be observed at the margin where the gall joins the leaf, even though on other parts of the gall-surface ascogenous cells have already been formed.

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genous cells of *T. californica* in a "trough" above the radial wall between two epidermal cells; I, mycelium of *T. laurencia* in the outer wall of an epidermal cell; J, ascogenous cells of *T. laurencia* from above, the host cells being incompletely covered by the fungus; K, asci of *T. amplians* protruding from a wall-locule; L, ascogenous cells of *T. rhomboidalis* from above; M, asci of *T. Tondusiana* protruding from a wall-locule.

No mycelium is ever found in the interior of the gall. It is confined to the surface and invariably begins its development (FIG. 1, *B*, *C*) within the outer epidermal wall. Treatment of sections with chloriodide of zinc shows that the mycelium grows between two layers of cellulose, the outer layer being covered by a thin cuticle.

In early stages the mycelium frequently grows above the radial walls of the epidermal cells (FIG. 1, *F*). As the hyphae broaden and thicken, the separated layers of the wall spread apart and the mycelium lies in a locule formed within the cell wall (FIG. 1, *D*). The locule is finally filled with close-packed, elongate ascogenous cells (FIG. 1, *E*). Frequently the locule appears as a trough above the radial wall between two epidermal cells (FIG. 1, *H*).

These locules, filled with ascogenous cells, together with the host cells unoccupied by the fungus, present a characteristic reticulate pattern (FIG. 1, *G*) when viewed from above.

When asci form, they burst the outer wall-layer and protrude from the locule as from a perithecium.

#### TAPHRINA LAURENCIA

This fungus has been studied from herbarium material (Sydow, *Fungi Exotici Exsiccati*, 421. Hakgala, Ceylon 3. 1914. T. Petch) borrowed from the University of Wisconsin Herbarium. It causes remarkable, branched outgrowths on the leaves of its host.

The outgrowths apparently represent modified leaves or leaflets and possess an upper and lower epidermis with a thin cuticle and interior mesophyll containing veins. The fungus is found in both epidermal layers of the outgrowth, the appearance being as described by Giesenhagen (2).

Actually the mycelium begins its development within the wall (FIG. 1, *I*) as in the preceding case. (In fact, one of Giesenhagen's figures shows this.) Enlargement of the mycelium and formation of ascogenous cells and asci depress the underlying wall-layer until the lumen of the epidermal cell is nearly closed.

This fungus differs from *T. californica* in that the mycelium does not grow above the radial walls of the epidermal cells but spreads over the outer wall of nearly every cell. The character-

istic pattern seen in tangential views of the *Dryopteris*-galls is therefore lacking. Often the mycelium fails to cover a cell completely, resulting in an appearance as shown in figure 1, J.

Dimensions of *T. laurencia* have somewhat wider limits than as given by Giesenhagen: asci  $23-33\ \mu \times 6-8\ \mu$ ; stalk cells  $17-30\ \mu \times 4-7\ \mu$ ; spores  $5-7\ \mu \times 2-4\ \mu$ .

#### TAPHRINA RHOMBOIDALIS

Another species, *Taphrina rhomboidalis* Sydow and Butl., occurs on the same host, *Pteris quadriaurita*. Instead of the remarkable outgrowths induced by *T. laurencia* this fungus causes small, unthickened spots. Since these spots are definitely bordered by the veins (although more than one vein-islet may be involved) they are distinctly rhomboidal in outline.

Two peculiarities of *T. rhomboidalis* were overlooked in the original description (7), first, that the ascus possesses a stalk cell, and second, that mycelium and ascogenous cells develop within wall-locules. The habit is quite like that of *T. laurencia*. When seen in surface view, however, the ascogenous cells are not regularly polyhedral in outline, as is the case with other species here discussed. On the contrary they are irregular in shape (FIG. 1, L).

The description of *Taphrina rhomboidalis* should be emended to include the features just mentioned and dimensions should be stated as follows: asci  $23-43\ \mu \times 8-10\ \mu$ ; stalk cells  $23-43\ \mu \times 4-5\ \mu$ ; spores  $4-7\ \mu \times 2-3\ \mu$ .

These dimensions are close indeed to those given above for *T. laurencia*. In fact there are only slight morphological distinctions between the two fungi. The distinguishing features of *T. rhomboidalis* are a somewhat narrower stalk cell and the irregular pattern of the ascogenous cells when viewed from above. The two species must be separated chiefly by the host-lesions which they induce. These are so strikingly different that it seems unlikely they could be caused by the same fungus. However, the occurrence on the same host of two species so similar as these finds no parallel elsewhere in the genus *Taphrina*.

The foregoing observations on *T. rhomboidalis* were made from material forwarded to the writer by G. Watts Padwick, Imperial Mycologist, New Delhi, India, at the instance of Dr. E. J. Butler.

This was evidently duplicate material of the type, having been collected in the Barma Gori Valley, Kumaon, Himalaya, June 24, 1907, by Inayat Khan.

#### TAPHRINA TONDUZIANA

A third species, *Taphrina Tonduziana* P. Henn., occurring on *Pteris aculeata* Sav. is also like *T. laurencia* in habit. It has been studied from original herbarium material collected at San Jose, Costa Rica, 1900, by A. Tonduz (Specimen borrowed from the Herbarium of the University of Michigan). This fungus causes small (5 mm. or less in diameter) brown unthickened spots on the leaves. The asci are formed in the central area of each spot on either the upper or under surface or on both. The lesions are like those caused by *Taphrina lutescens* Rostr. on leaves of *Thelypteris thelypteris* (L.) Nieuwl.

As in the species just discussed, two peculiarities of *T. Tonduziana* were overlooked in the original description by Hennings (3): "ascis caespitosis, clavatis, apice rotundatis, vel subapplanatis, 8-sporis,  $16-24\ \mu \times 6-8\ \mu$ ." The asci possess stalk cells (asci  $20-30\ \mu \times 7-8\ \mu$ ; stalk cells  $10-17\ \mu \times 5-7\ \mu$ ; spores  $5-7\ \mu \times 2-3\ \mu$ ), and the fungus displays the "wall-habit" of growth. Mycelium grows within the outer wall of an epidermal cell, ascogenous cells are formed in a wall-locule, and the asci burst out of the locule exactly as in *T. laurencia* (FIG. 1, *M*).

#### *Taphrina ampliars* sp. nov.

Mycelio in loculis in muris cellularum epidermidis utraeque paginae folii crescente; ascis ex illis loculis erumpentibus, aureis, clavatis, apice rotundatis vel truncatis,  $26-36\ \mu$  longis  $\times 8-10\ \mu$  crassis, cellula basilari cylindrata,  $23-40\ \mu \times 5-8\ \mu$ ; ascosporis octonis, hyalinis,  $5-6.5\ \mu \times 2-3\ \mu$ . Folia aurea colorans et illa longiora latioraque sed non crassiora reddens. In foliis vivis *Pteridis orizabe* Mat. et Gal. Santa Maria de Jesus, Quetzaltenango, Guatemala, December 28, 1936, leg. J. H. Faull.

Mycelium developing in wall-locules of the epidermis of each surface of the leaf, at maturity bursting out of these locules; ascogenous cells and asci colored golden yellow, asci clavate, rounded or truncate at apex,  $26-36\ \mu \times 8-10\ \mu$ ; stalk cells cylindric,  $23-40\ \mu \times 5-8\ \mu$ ; ascospores eight, hyalin,  $5-6.5\ \mu \times 2-3\ \mu$ . Inducing considerable expansion of leaf blade but no thickening. Affected areas colored golden yellow. Attacking living leaves of *Pteris orizabe* Mat. and Gal.

Type material: Herbarium of J. H. Faull, No. 12939.

For material of this fungus and for permission to describe it, the writer is indebted to Dr. J. H. Faull. Determination of the host-species was kindly made by Mr. C. A. Weatherby of the Gray Herbarium.

Affected leaflets are shown in figure 2, *B*. Development of

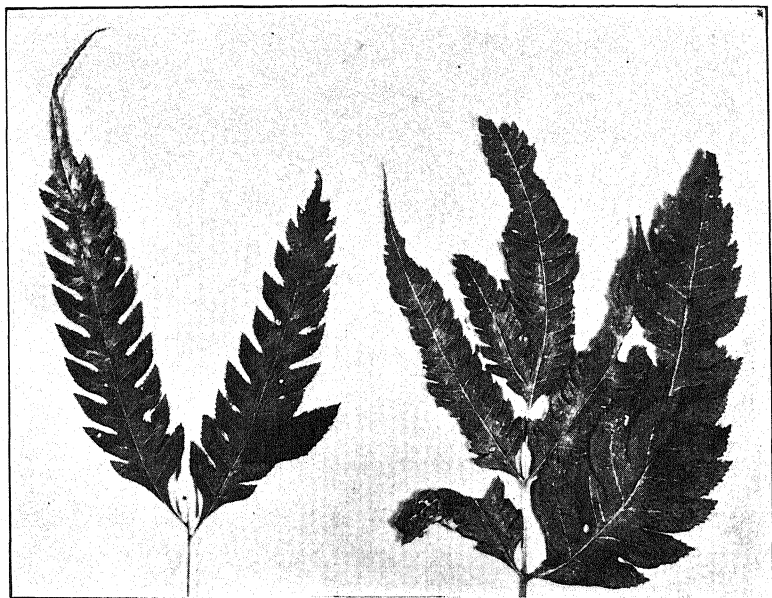


FIG. 2. Portions of fronds of *Pteris orizabe* affected by *T. amplians*. Diseased leaflets are laterally enlarged but not thickened.

mycelium, ascogenous cells and asci takes place within the outer epidermal wall. The fungus is like *T. laurencia* in growing above the cell cavities, not above the radial walls between epidermal cells. It is unique among all known species of *Taphrina* on ferns in that its ascogenous cells and young asci contain a golden-yellow, oily substance, thus resembling *Taphrina aurea*, *T. flava*, etc. Mature asci of *T. amplians* are shown in figure 1, *K*.

#### ***Taphrina Thaxteri* sp. nov.**

Mycelio in loculis in muris cellularum epidermidis paginae inferioris folii crescente; ascis hypophyllis, ex loculis erumpentibus, clavatis, apice rotun-



dati vel truncatis, 20–27  $\mu$  longis  $\times$  5–7  $\mu$  crassis, cellula basilari cylindrata, 7–15  $\mu$   $\times$  5–7  $\mu$ ; ascosporis saepe fusiformis, 3.5–5  $\mu$   $\times$  2–3  $\mu$ . Maculas flavas parvas (usque ad 1 cm. diam.) gignens in foliis *Dryopteridis Poiteanae* (Bory) Urban. Haud deformans. Verdant Vale, Arima, Trinidad. leg. R. Thaxter.

Mycelium growing in locules in walls of lower epidermal cells, asci hypophyllous, emerging from the locules, clavate, rounded or truncate at apex, 20–27  $\mu$  long  $\times$  5–7  $\mu$  wide; stalks cells 7–15  $\mu$   $\times$  5–7  $\mu$ ; spores often spindle-shaped 3.5–5  $\mu$   $\times$  2–3  $\mu$ . Causing pale-yellow, small (1 cm. or less) unthickened spots on leaves of *Dryopteris Poiteana* (Bory) Urban. Verdant Vale, Arima, Trinidad. R. Thaxter.

Type material in Mycological Herbarium, University of Kansas and in Farlow Herbarium.

This fungus from among the Thaxter collections in the Farlow Herbarium (the packet bears no date) was received from D. H. Linder. The host-species was determined by C. A. Weatherby of the Gray Herbarium.

*Taphrina Thaxteri* bears close resemblance to *T. Tonduziana* not only in its habit of growth within the wall, but in the size of its asci and stalk cells. It differs in the shape and dimensions of its spores and in possessing a hypophyllous hymenium (amphigenous in *T. Tonduziana*). The host plants are not closely related and unless later collections show similar fungi on a variety of fern-species, it seems unlikely that the two species here distinguished will later prove to be identical.

#### TAPHRINA MACULANS

Through the kindness of Dr. D. H. Linder, of the Farlow Herbarium, the writer has been privileged to examine material of *Taphrina maculans* Butl. on *Curcuma longa* L. The excellent account of Butler (outlined earlier in this paper) has been confirmed. Butler, however, speaks of the early "subcuticular" growth of the mycelium when he apparently means lateral growth within the wall. The fungus seems to grow within the wall from the first.

#### TAPHRINA LINEARIS

In the description of *Taphrina linearis* Sydow, occurring on *Globba marantina* L., the authors Sydow and Sydow (6) do not

discuss the growth of this fungus within the host-cell wall. However, the technical description is given in language identical with that employed by Butler (1) in describing *T. maculans*: "hyphis sterilibus inter parietes cellularum epidermidis et hypodermidis crescentibus." It is probable that they were here referring to growth within walls rather than between them.

Material of this fungus (also received from the Farlow Herbarium) shows it to be like *T. maculans* in mycelial habit.

#### DISCUSSION

The eight species of *Taphrina* discussed above constitute a group, set off from other species by their habit of growth within cell walls, this "wall-habit" reaching its greatest development in *T. maculans* and *T. linearis*. Were there any point in recognizing subgenera, these eight species might be included in the subgenus *Taphrinopsis* of Giesenhagen (2). This subgenus, which till now has included only *Taphrina laurencia*, was proposed for forms developing within epidermal cells. The subgeneric description would, of course, need to be revised.

In the present imperfect state of our knowledge of the genus *Taphrina*, it would be idle to conjecture whether the "wall-type," the subcuticular, or the intercellular type of mycelial habit is the more primitive. Certainly the "wall-type" was reached early in the development of the genus, since six of the eight species exhibiting it occur on ferns. The other two, however, parasitize monocotyledons.

Separation of the wall-layers by these forms does not appear to be by mechanical splitting. Swelling of the walls with sulfuric acid does not show any distinct lamination which would allow for such splitting. It seems more probable that the fungi secrete a cellulose-dissolving enzyme. However, cellulose is apparently not utilized to any extent, since the two layers of the divided wall, taken together, are not measurably thinner than the undivided wall. In the case of *Taphrina californica* the wall separating the fungus from the epidermal cell beneath seems to undergo some additional thickening, presumably due to protective reaction on the part of the host protoplasm. This wall is often noticeably thickened, colors deeper yellow than other walls when treated with sulfuric acid, and is the last wall to dissolve in that reagent.

## SUMMARY

Eight species of *Taphrina*: *T. californica*, *T. laurencia*, *T. rhomboidalis*, *T. Tonduziana*, *T. amplians*, *T. Thaxteri*, *T. maculans*, and *T. linearis*, form mycelium within the outer wall of the host-epidermal cell, and produce ascogenous cells and asci in a wall-locule. This fact has been previously reported only for *T. maculans* (a fungus which also develops mycelium within the radial epidermal walls), although *T. laurencia* was described by Giesenhagen as occurring within the outer part of an epidermal cell. Six of these wall-inhabiting species parasitize ferns, the other two are found on monocotyledons.

Two of the above-named species: *Taphrina amplians*, occurring on *Pteris orizabe*, and *T. Thaxteri* on *Dryopteris Poiteana* are new to science. Two others, *Taphrina rhomboidalis* and *T. Tonduziana* were till now inadequately described.

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# A CANKER DISEASE OF POPLARS CAUSED A NEW SPECIES OF NEOFABRAEA

G. E. THOMPSON<sup>1</sup>

(WITH 3 FIGURES)

The disease was first observed at Bear Island, Lake Temagami, Ontario, during the summers of 1930–1931, when it was found on young trees of *Populus grandidentata* Michx., *P. tacamahaca* Mill. and *P. tremuloides* Michx. Later it was found on the same species of poplars in other places in the Temagami Forest Reserve. The affected trees were from three to six years old and usually not over 1.5 inches in diameter.

Cankers were generally located near the base of the tree, although occasionally they were found on the stem a few feet above the ground. In a few cases cankers had caused the death of trees.

## SYMPTOMS

Incipient infections appear as small depressed areas in the bark. These are frequently accompanied by a swelling at the margin and a longitudinal splitting of the bark in the central portion of the lesions. Older cankers may be from four to six inches in length, elliptical in outline and girdling the stem for one-half or more of its circumference. The bark in the center of the canker is slightly sunken and split vertically, especially at the margins adjacent to the callus (FIG. 1A). In some cases, cankers completely encircle the stems without any callous formation. They appear as slightly sunken areas surrounding the stem.

In a cross section through the cankered area, the wood is brown-

<sup>1</sup> The investigations reported in this paper were undertaken during the tenure of a scholarship from the National Research Council at the University of Toronto, Toronto, Canada, during 1930–1931. They were continued at Cornell University, Ithaca, N. Y. The author wishes to express his sincere thanks to Professor H. S. Jackson and Dr. J. W. Groves for their assistance in the identification of the fungus. All photographs, with the exception of figure 1B, were made by Mr. W. R. Fisher of the Department of Plant Pathology, Cornell University, Ithaca, N. Y.

ish in color. The discoloration often extends to the pith in a wedge-shaped formation or it follows certain of the annual rings for part of the way around the circumference.

#### ETIOLOGY

*Perfect stage:* The perfect stage of the fungus which causes the disease is a small discomycete which possesses certain characters resembling members of the family Dermateaceae. At the suggestion of Dr. J. W. Groves it was compared with material of *Neofabraea malicorticis* (Cordley) Jackson. As a result of the examination, it is concluded that the two fungi are congeneric.

The genus *Neofabraea* was erected by Jackson (2) with the following diagnosis: "Characteristics in general like *Pseudopeziza*. Apothecia developing in and at length breaking forth from a more or less exposed subiculum consisting of the old conidial bearing stroma. Spores at first one-celled at length two-four celled." His species *N. malicorticis*, has for its conidial stage *Gloeosporium malicorticis* Cordley. Jørgensen (3) described a second species in the genus as *N. corticola* (Edgerton) C. A. Jørg. which has for its conidial stage *Myxosporium corticolum* Edgerton.

Nannfeldt (4) after an examination of *Neofabraea corticola* made the genus a synonym of *Pezicula* Tul. and erected the new combinations, *Pezicula malicorticis* and *P. corticola*. He also transferred the conidial stages to the genus *Cryptosporiopsis* Bubak and Kabat (1) which has oblong-ellipsoid conidia. In making the transfer of the genus *Neofabraea* to *Pezicula* Nannfeldt apparently did not see the type of the genus, *N. malicorticis*, but based it on material of *N. corticola* which is a good *Pezicula* and should have been placed in that genus originally. It appears therefore, that the genus *Neofabraea* while probably related to *Pezicula* and other genera of the Dermateaceae through the characters of the apothecia and conidial stages should not be regarded as a synonym of *Pezicula* but as a good genus.

A survey of the literature shows that no species of this genus has been reported as a parasite on poplars. It is therefore described as a new species and the following name is proposed:

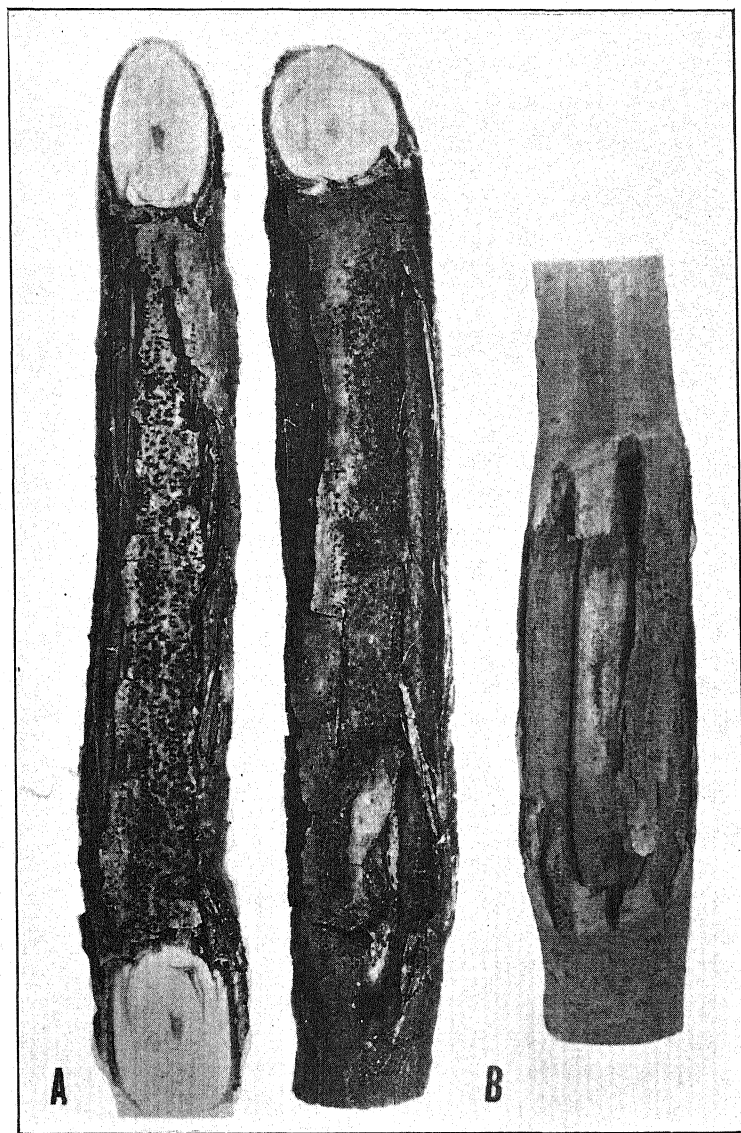


FIG. 1. *A*, cankers on *Populus tremuloides*, approx.  $\times 1$ ; *B*, canker on *P. grandidentata* with part of bark sloughed away, approx.  $\times 1$ .

**Neofabraea Populi** sp. nov.

Apotheciis leniter erumpentibus, solitariis, dense sparsis, 0.5–1.5 mm. diam., carneis vel brunneolis, carnosus vel ceraciis, umbilicatis, convexus in humido, planis in exsiccatis, stromatis prosenchymaticis, hyalinis; ascis cylindrico-clavatis, brevissimis stipitatis,  $80\text{--}115 \times 9.5\text{--}12.5 \mu$ , octosporis; ascosporis, irregulariter distichis, elliptico-oblongis, rectis vel leviter curvatis, hyalinis, continuis vel triseptatis,  $16\text{--}22 \times 5\text{--}6.5 \mu$ ; paraphysibus filiformibus, septatis, simplicibus vel ramosis  $2\text{--}3 \mu$  diam. apice incrassato, hyalinis, epithecium formantibus.

Status conidicus; acervulis 0.5–1.5 mm. diam., leniter erumpentibus, sparsis, stromatis, prosenchymaticis, hyalinis; hyphis fertilibus, hyalinis, septatis, simplicibus vel ramosis,  $25\text{--}35 \times 4 \mu$ ; conidiis cylindraceis vel fusiformibus, rectis vel curvatis, hyalinis, continuis,  $25\text{--}45 \times 4.5\text{--}5 \mu$ .

TYPE LOCALITY: Bear Island, Lake Temagami, Ontario, Canada.

TYPE SPECIMENS: Author's number 494 on *Populus tremuloides* Michx. Specimens from the same collection have been deposited in the Department of Botany, University of Toronto, Toronto, Canada, as number 2046, and in the Department of Plant Pathology Herbarium Cornell University, Ithaca, N. Y., as number 23994. Specimens have also been placed in the New York Botanical Garden Herbarium.

Mature apothecia were collected during June, July and August. They are scattered thickly over the dead bark. The majority of the apothecia occur singly, a few confluent (FIG. 2A). A few apothecia were found on the exposed wood where the bark had sloughed away from the canker. The apothecia are flesh-colored to light-brown when fresh, becoming darker when dry, fleshy to waxy in consistency, 0.5–1.5 mm. in diameter, convex when moist, flat to slightly concave when dry, circular to irregular in outline, umbilicate, except when produced on the exposed wood, borne on a slight stroma formed between the cork and cortex, finally exposed by rupturing of the outer corky layers; stroma about  $100\text{--}150 \mu$  in thickness, composed of loosely arranged, narrow oblong to globose, hyaline hyphae, area immediately beneath the asci composed of narrow compact vertical rows of hyaline hyphae (FIG. 2B and C); excipulum consisting of narrow, brownish obliquely-arranged hyphae; asci cylindric-clavate, short stalked,  $80\text{--}112 \times 9.5\text{--}12.5 \mu$ , eight spored (FIG. 3A); ascospores irregularly biseriate, oblong-ellipsoid, straight to slightly curved, occasionally flattened on one side, contents granular, hyaline, one to four celled,  $16\text{--}22$

$\times 5\text{--}6.5\ \mu$  (FIG. 3C); paraphyses filiform,  $2\text{--}3\ \mu$  wide, hyaline, septate, simple or branched, slightly swollen at the tips (FIG. 3B), forming an epithecium.

*Conidial stage:* The conidial stage of the fungus is a member of the form genus *Myxosporium*. It frequently was found associated with the apothecia. In several collections, the apothecia occupy the central portion of the diseased area while the conidial stage appears at the margin.

The acervuli  $0.5\text{--}1.5$  mm. in diameter originate between the cork and cortex of the bark, finally becoming exposed by rupturing of the outer corky layers (FIG. 3D); stroma of the acervulus  $35\text{--}50\ \mu$  in thickness, composed of interwoven, narrow, hyaline hyphae; conidiophores, septate, simple or branched hyaline  $25\text{--}35 \times 4\ \mu$  (FIG. 3F); conidia borne singly at the tips of the conidiophores, cylindric-fusiform, ends slightly pointed, straight or curved, one celled, contents granular, hyaline,  $25\text{--}45 \times 4.5\text{--}5\ \mu$  (FIG. 3G) oozing out on the surface of the bark in pinkish masses, whitish when dry.

#### CULTURES

The fungus was isolated in pure culture from ascospores, conidia and tissue plantings of the diseased bark. The cultures derived from these sources were similar one to another.

Ascospores germinated on potato dextrose agar in three to four hours at laboratory temperatures. A single germ tube developed at the end or side of each spore (FIG. 3D). When ascospores were germinated in sterile distilled water or sterile lake water, narrower germ tubes were formed. Frequently instead of producing germ tubes the ascospores formed numerous oval to elliptical one celled hyaline spores  $4.5\text{--}8 \times 1.5\text{--}2.5\ \mu$ , resembling microconidia. These were budded off from the sides of the ascospores (FIG. 3E). A similar production of microconidia from ascospores was observed in mounts of crushed apothecia which were kept in moist chambers. No germination of the microconidia was observed.

The conidia germinated on potato dextrose agar in six to seven hours at laboratory temperatures. Germ tubes were produced from the ends or sides of the spores (FIG. 3I).



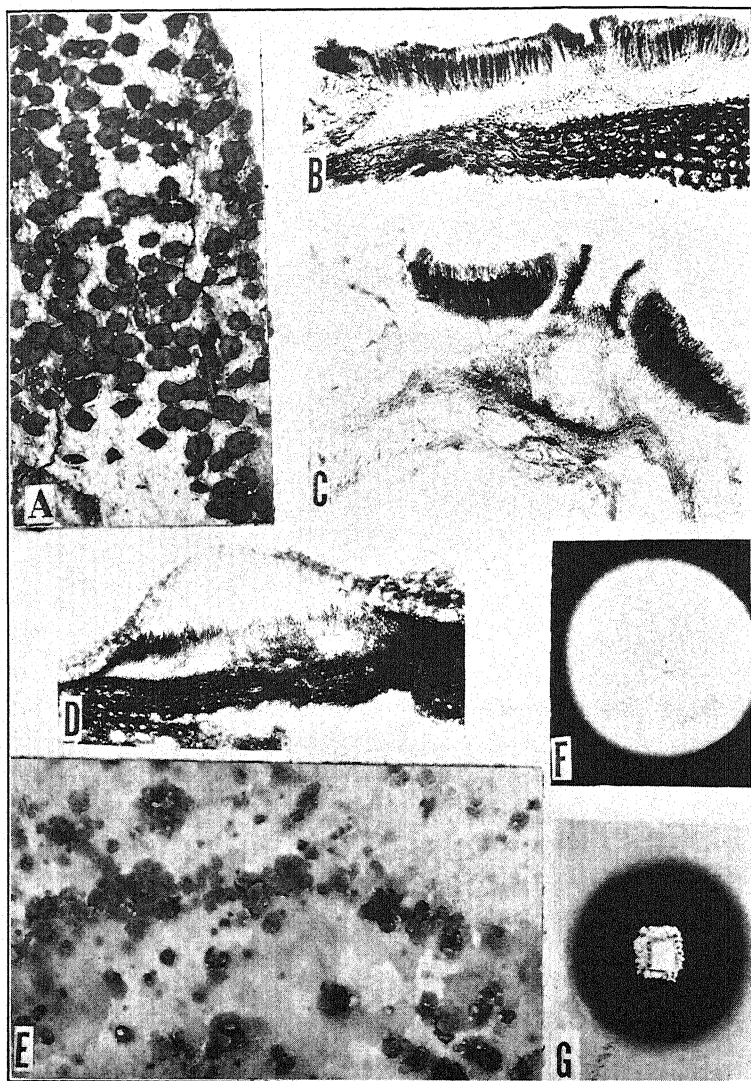


FIG. 2. *A*, mature apothecia on bark of *P. tremuloides*, approx.  $\times 3$ ; *B*, *C*, free hand sections of apothecia stained with cotton blue and mounted in lacto-phenol, approx.  $\times 60$ ; *D*, free hand section of an acervulus stained with cotton blue and mounted in lacto-phenol, showing the stroma with conidiophores and conidia, approx.  $\times 60$ ; *E*, apothecia formed on cornmeal agar, approx.  $\times 2$ ; *F*, mycelial growth of the fungus on potato dextrose agar; approx.  $\times 1$ ; *G*, mycelial growth of the fungus on oatmeal agar, approx.  $\times 1$ .

The mycelium on potato dextrose agar formed a rather dense cottony aerial growth which later became brownish in patches (FIG. 2F). Conidia were not always formed on this medium.

On oatmeal agar the fungus produced very little aerial mycelium and the medium was stained a dark reddish-brown (FIG. 2G). Conidia were produced quite readily developing within seven to ten days after the cultures were started (FIG. 3H). They appeared as pinkish masses about 0.5–1.5 mm. in diameter exuding from a poorly developed fruiting body resembling an acervulus. The conidia were similar to those found in acervuli in the bark of diseased stems.

On cornmeal agar the fungus appeared as a superficial, loose cottony mycelium, whitish at first, becoming brownish with age. Conidia were produced abundantly within a period of seven days. They developed in fruiting bodies similar to those observed on oatmeal agar.

#### TEMPERATURE STUDIES

Duplicate sets of petri dishes containing 20 cc. of potato dextrose agar inoculated with pieces of mycelium 5 mm. in diameter were placed in each of the constant temperature chambers. At the end of twenty days the diameters of the colonies were measured and an average obtained for each set of duplicates.

The optimum temperature for growth of the fungus was found to be approximately 18° C. Some growth occurred at 3° and some at 27° C.

Corresponding results were obtained when the fungus was grown at the same temperatures on slants of potato dextrose agar in test tubes. Conidia were present in this series of cultures at temperatures of 3°, 6°, 9°, 12°, 15°, 18°, and a few at 21° C. They were not found in cultures kept at 24° and 27° C. The conidia found in cultures kept at 3° and 6° C. were for the most part atypical. They varied from oval to elliptical, hyaline spores,  $6.5-9 \times 3.5 \mu$  to those oblong-ellipsoid to dumb-bell shaped,  $13-19 \times 4.5-6.5 \mu$  (FIG. 3J). At temperatures of 9°–18° C. typical conidia were usually produced although at 9° C. both typical and atypical conidia developed.

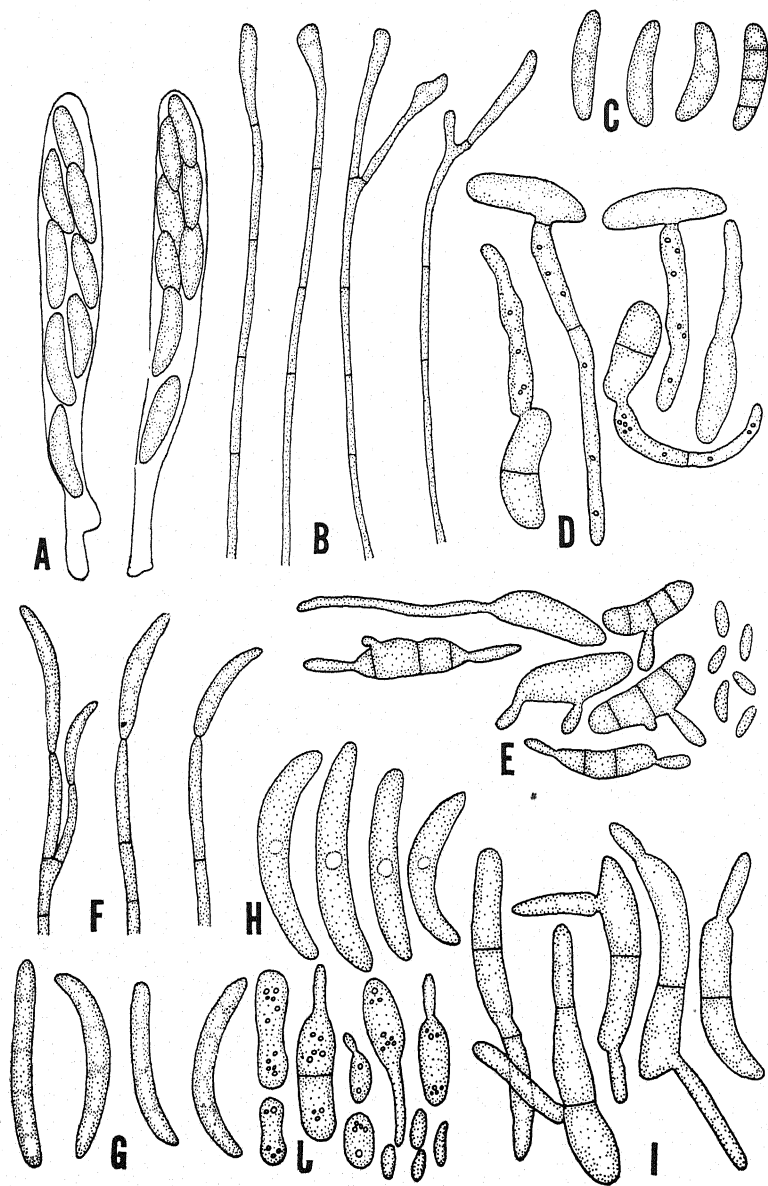


FIG. 3. *A*, asci with ascospores; *B*, paraphyses; *C*, ascospores; *D*, ascospores germinated on potato dextrose agar; *E*, ascospores germinated in sterile distilled water, showing microconidia budding off from the side of the spores; *F*, conidiophores with conidia; *G*, conidia; *H*, conidia produced

## PRODUCTION OF APOTHECIA IN CULTURE

On April 6, 1934, transfers from a mass ascospore isolation were made to two petri dishes of cornmeal agar. These petri dishes were placed in the constant temperature chamber at 15° C. On August 7, 1934, the plates were examined and apothecia with mature asci and ascospores were found. Both single ascospores and ascospore masses were isolated and grown on cornmeal agar in petri dishes. The cultures were kept in the constant temperature chamber at 15° C.

During the course of the investigation a total of twenty-three single ascospores were isolated and grown under the above conditions. Five of these produced apothecia with asci and ascospores. The remainder produced sterile apothecia. Seventeen cultures derived from polyascospores were also set up under the same conditions. Twelve of these produced apothecia with asci and ascospores (FIG. 2E), while five yielded sterile apothecia.

The apothecia developed first near the middle of the plate about forty-five days after the cultures were started and later appeared scattered over the surface of the medium. They occurred singly or in groups of two to four, light brown in color, about 1 mm. in diameter, somewhat fleshy to waxy in consistency, convex, paraphyses present. The umbilicate character of the apothecia found in nature was not found in apothecia produced in culture. However the asci and ascospores were similar to those found in the apothecia on the diseased bark.

The sterile apothecia resembled the fertile ones in outward appearance, but the hymenium instead of producing asci was filled with sterile threads resembling paraphyses.

The production of apothecia in culture from single ascospores indicates that the fungus is homothallic. The failure to obtain fertile apothecia in certain cultures may have been due to some unfavorable condition of the environment.

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in culture; *I*, conidia germinated on the surface of potato dextrose agar; *J*, atypical conidia found in cultures which were grown at temperatures of 3° and 6° C. *A*, *B*, *C*, *F*, and *G* made from lacto-phenol mounts. Others made from fresh material mounted in water. × 835.

## INOCULATIONS

Disease-free trees of *Populus grandidentata* one to four inches in diameter were selected for field inoculations. A "T" shaped slit was made in the bark and an agar block of mycelium from a culture inserted under one edge of the incision. This portion of the stem was enclosed in a celluloid cylinder and the ends plugged with moist sphagnum. The chamber thus formed was left attached to the tree for a period of five days. During that interval the sphagnum was kept moistened.

On July 10 and 28, 1930, seven inoculations were made on the lower part of the stems just above the ground. A different tree was used for each inoculation.

On June 25, 1931, the trees were examined. Six of the seven inoculations were successful. Cankers were developing and acervuli with typical conidia were present around the margins of the affected parts. Isolations of the fungus were made from the conidia and diseased bark. The cultures were similar to those made from ascospores and conidia from naturally infected trees.

## SUMMARY

1. A canker disease affecting trees of *Populus grandidentata*, *P. tacamahaca*, and *P. tremuloides* was found in the Temagami Forest Reserve, Ontario, Canada.
2. The fungus causing the disease is described as *Neofabraca Populi*. Its conidial stage is a member of the form genus *Myxosporium*.
3. The fungus was isolated from ascospores, conidia and tissue plantings from the diseased bark and grown on various media. The cultures derived from these sources were similar to one another.
4. The optimum temperature for growth of the fungus was found to be approximately 18° C. Some growth occurred at 3° and at 27° C.
5. Apothecia were developed in pure cultures on cornmeal agar. Both single and polyascosporic isolations produced apothecia in about forty-five days when grown at a temperature of 15° C.

6. The pathogenicity of the fungus was demonstrated by artificial inoculations made to small trees of *Populus grandidentata*. The fungus was re-isolated in pure culture.

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## NORTH AMERICAN POLYPORES—II. POLYPORUS BIENNIS AND ITS VARIETIES

PAUL W. GRAFF

*Polyporus biennis* and its varietal segregates possess quite variable characteristics. They have masqueraded among the poroid Boleti and Polypori, the labyrinthine Daedaleae and the echinoid Sistotrematae, not to mention that group of contortionists, the genus *Abortiporus*, created by Murrill for the reception of a member of this group. They have finally come to rest, as appears most appropriate, in the genus *Polyporus*.

Of the five fungi considered here *Polyporus biennis*, apparently, has not been collected in North America, but is typically European. The remaining four are varieties of this species. Though the first of these has been reported from the United States this was without justification. Our present knowledge indicates the last three to be wholly American in their distribution.

Bulliard (1789) first described and figured *Polyporus biennis*, and placed it in the genus *Boletus*. A few years later Persoon (1797) conceived a need for the genus *Sistotrema*, and subsequently (1801) included Bulliard's species within this group. As first instituted *Sistotrema* is located between the genera *Boletus* and *Poria*, and contained but two species, *S. confluens*, based upon *Hydnum sublamellosum* Bull., and *S. cinereum*, based upon *Boletus unicolor* Bull. With his customary naivete Persoon changes these specific names without offering excuse or reason.

In his "Synopsis" Persoon extends *Sistotrema* to include twelve species. These are about evenly divided between forms gleaned from the genus *Hydnum*, and near relatives, and from *Boletus* as interpreted by Bulliard. In an appended foot-note Persoon says briefly, "Intermedium genus est inter Boletum et Hydnum." Persoon considered *Sistotrema* as a repository for certain species which he believed transitional in nature and properly located between the Polyporaceae and Hydnaceae.

Whatever may be the final appearance among old specimens of these fungi they are primarily polyporoid in nature. As they develop, inhibitions may appear in the growth of portions of the tubes or, through the laceration of their dissepiments, a camouflaged state may be produced. Whether this echinoid tendency is of much phylogenetic importance may be considered questionable. While it is admissible that these fungi may show transitional tendencies, they are not sufficiently well marked to exclude them from the Polyporaceae. If *Polyporus biennis* belongs to a group closely related to the Hydnaceae what of its labyrinthine pores and their significance?

In his original description Bulliard (1789) describes the pores of *Polyporus biennis* as irregular in form and exceedingly variable. In his plate 449 they are shown as distinctly sinuous and daedaloid. In recognition of this Fries (1821) placed the species in the genus *Daedalea*. Later (1838), however, he concluded that the fungus was primarily polyporoid, and removed it to *Polyporus*.

The basis upon which members of the genus *Polyporus*, having sinuous or labyrinthine pores, are distinguishable from true members of the genus *Daedalea* is frequently overlooked. While necessarily of a more or less relative nature, if taken into account, the species may be readily separated. If applied in the present instance there should be no hesitancy in placing any of the several forms we are to consider in their proper generic position. The presence of labyrinthine pores is not in itself a sufficient diagnostic character, but the nature of these pores, and their dissepiments, may be of considerable importance. Though briefly stated, the following should be sufficient aid in separating members of the genus *Polyporus* with daedaloid pores from true members of the genus *Daedalea*.

DAEDALOID POLYPORE: Tube layer distinct but not separable from the context; tubes of equal length, forming a homogeneous layer; pileus fleshy, leathery to woody, stipitate or sessile, rarely resupinate; context often soft at first, fibrous, spongy, fleshy or firm, rarely suberose or woody; pores slender, narrow, having thin dissepiments whose edges frequently become irregular or lacerate.

DAEDALEA: Tube layer not distinct or separable from the context; tubes immersed in the flesh of the pileus to varying depths;



pileus suberose, sessile or resupinate; context firm, suberose, rarely woody; pores usually broader and more contorted, having corky and relatively thick dissepiments whose edges are more often smooth, when lacerate or toothed such condition does not extend to the marginal pores.

On the basis of the above Bulliard's *Boletus biennis*, and its several varieties as interpreted in this paper, belong in the genus *Polyporus*.

1. POLYPORUS BIENNIS (Bull.) Fries, Epicr. Syst. Myc. 433. 1838.

*Boletus biennis* Bull. Herb. Fr. *pl.* 449. 1789.

*Sistotrema biennis* (Bull.) Pers. Syn. Fung. 550. 1801.

*Daedalea biennis* (Bull.) Fries, Syst. Myc. 1: 332. 1821.

*Daedalea albida* Purt. Brit. Pl. 3: 253, *pl.* 38. 1821.

*Sistotrema rufescens* Pers., var. *bienne* (Bull.) Pers. Myc. Eu. 2: 207. 1825.

*Polyporus heteroporus* Fries; Qué. Champ. Jura, Vosges 257. 1872. Not Mont.

*Daedalea pampeana* Speg. Anal. Mus. Nac. Buenos Aires II. 6: 175. 1899.

*Daedalea bonariensis* Speg. Anal. Mus. Nac. Buenos Aires III. 1: 52. 1902.

Basidiocarp solitary and simple or imbricated from a short, simple stipe, or sessile; pileus convex at first, then plane to depressed, occasionally dimidiate, 3–12 cm. broad when solitary, when imbricated somewhat broader, 0.5–1.5 cm. thick; surface scurfy-tomentose to strigose, becoming more or less subglabrous in age, flesh-colored or light reddish-brown, rarely yellowish, in the center, with a, usually wide, white margin, azonate; margin variable, thin and acute to thick and obtuse, usually fertile below, reflex to repand; context white when fresh, becoming light tan when dry, duplex, with the upper layer soft and spongy and the lower firm and coriaceous, 0.3–1 cm. thick, hyphae rarely branching, with walls of variable thickness, 3–7.5  $\mu$  in diameter; tubes white, then flesh-colored to ashen when dry, labyrinthiform or sinuate, very unequal, approximately 48 per sq. cm., somewhat decurrent, dissepiments thin, entire at first, more or less lacerate-dentate in age, frequently pruinose; stipe short, thick, subcentral to lateral, sometimes wanting, 1.5–2 cm. long, 1–5 cm. thick, concolorous with the center of the pilear surface, woody, subtomentose to

lanate; basidia elongate-clavate,  $20-30 \times 5-7 \mu$ ; spores ellipsoid to broadly ovoid,  $5-7 \times 3.5-5$  ( $6 \times 4$ )  $\mu$ , hyaline, smooth, apiculate, with a large central guttation.

TYPE LOCALITY: France.

HABITAT: Decaying wood, tree stumps, roots, and sometimes appearing on soil but then from buried wood.

DISTRIBUTION: Europe; South America; Queensland, Australia (Cooke). Late Autumn.

ILLUSTRATIONS: Bulliard, Herb. Fr. *pl.* 449. 1789; Nees, Syst. Pilze Schw. *pl.* 30, fig. 228. 1817; Purton, Brit. Pl. 3: *pl.* 38. 1821, as *Daedalea albida*; Gillet, Champ. Fr. 5: *pl.* 161. 1897.

At present any statement regarding the distribution of *Polyporus biennis* must be discounted to a certain extent. This is because of the confusion in identity which has existed between this species and the fungus generally known as *P. rufescens*. For example, we find that Winter (1884) recognizes *P. biennis* and *P. rufescens* as distinct species. He includes *Daedalea rufescens* (Pers.) Fries, in his synonymy of *P. biennis*, and *Sistotrema rufescens* Pers., in that of *P. rufescens*. As *S. rufescens* is the Persoonian fungus which Fries removed to the genus *Daedalea* it is obvious that Winter has not aided in the clarification of the situation. Rea (1922) considers *P. biennis* and *P. rufescens* to be synonymous, and apparently reached this conclusion by accepting Sowerby's interpretation of Bulliard's species without reference to Bulliard's original description and most excellent plate. More definite knowledge respecting the geographic distribution and host range of these two fungi is highly desirable, but the validity of this data depends upon a clearer understanding of their characteristics and distinctions.

In connection with variability of the pores in *Polyporus biennis*, it seems that where these are less daedaloid and more rounded than usual the dissepiments are thicker. Such variation in the Polyporaceae is usually associated with a rapid development and early maturing in the presence of greater humidity and higher temperature than normal. The pores in such cases are frequently more shallow than in the typical state.

It should be noted also that it is only among older and larger forms that the considerably lacerated dissepiments of the pores

give any chance resemblance to members of the Hydnaceae. With regard to the white margin on the upper surface of the pileus there is much variability. In young, rapidly growing specimens this is frequently as wide as a quarter or even half the radius of the cap. In the case of slower growing plants, or older specimens where the growth activities are slowing down, the width of this white margin often becomes much diminished in proportion to the colored center.

In his earlier publication, as I have already pointed out, Fries (1821) transferred *Boletus biennis* Bull., to the genus *Daedalea*, but later (1838) removed the species to the genus *Polyporus*. Subsequently Fries communicated the description of a fungus, under the name of *P. heteroporus*, to Quélet, who published it (1872) in his "Champignons du Jura," where he gives Fries due recognition as the author. Later we find that Quélet (1886), who maintained *P. biennis* as a *Daedalea*, recognized the fact that *P. heteroporus* and *D. biennis* are undoubtedly identical and reduced the former to synonymy.

Another early description of *Polyporus biennis* was published by the English botanist Thomas Purton (1821), who described it as a "Fawn-colored *Daedalea*" under the scientific name of *Daedalea albida*. His description is accompanied with an excellent colored plate that leaves no doubt as to the fungus with which he was dealing. In connection with his description he says that he adopted Withering's specific name on the same principal that gentleman adopted it from Schaeffer. "The term *albidus*," he says, "by no means applies to the plant in the state I have found it." His plate clearly shows a fungus with the flesh-colored center and white margin, as well as the pore characters, of *P. biennis*. While Purton gives three synonyms, "*Daedalea alba* Batt.," "*Boletus albidus* Schaeff.," and "*Boletus rugosus* Sowerby," he questions all as to identity with his species, and is quite justified in doing so.

It would seem that Purton did not have the excuse Withering (1796) had in appropriating the name *albida*. The fungus Withering described was, in all probability, the same as that described and illustrated by Schaeffer (1763, pl. 124) as he claimed, and seems to be, without question, *Polyporus albidus* (Schaeff.) Secr., otherwise known as *P. caesius* Fries. "*Daedalea alba*

Batt.," is in the peculiar position of never having existed. We have a strange condition here for the fungus to which Purton refers is designated by Battarra as *Agaricus daedalaeis sinibus excavatus* Tou. Battarra used no such binomial as "*Daedalea alba*" in either this or any other connection. Battarra's (1775, pl. 38, fig. A) plant, to which reference is made, may be the same species as described by Schaeffer, but both description and plate are too inadequate for any satisfactory interpretation. However, one can positively say that this is not the species with which Purton was dealing. In the case of "*Boletus rugosus* Sowerby" (Sowerby 1815, pl. 422), there can be no doubt but that this is *B. rugosus* Pers., a fungus now usually recognized as *Polyporus alligatus* Fries.

While Purton's description is not as complete as one might desire, his plate 38 is an excellent representation of the larger imbricated form of *Polyporus biennis*. It conforms well with the original description offered by Bulliard, and supplements his plate in which the simple type of basidiocarp is shown.

Persoon (1825) recognized the close relationship of *Polyporus biennis* to his *Sistotrema rufescens*, and proposed to make the former a variety of the latter. Apparently Persoon believed his *S. rufescens* to be more general in its distribution than *P. biennis*, and consequently better in the position of species than as a variety. As it happens, however, Fries (1821) had already proposed considering the rufescent variety of this fungus as a variety of *P. biennis* when he recognized Sowerby's (1799, pl. 191) English fungus as differing from that described by Bulliard, and published it as var. *Sowerbei*. By some strange oversight this action of Fries seems to have been entirely overlooked.

Spegazzini (1899) described, as *Daedalea pampeana*, a fungus purporting to be a new species from the "Parque de la Plata," and later (1902) another, as *D. bonariensis*, from the vicinity of Buenos Aires. Bresadola (1916) came to the conclusion that these two fungi are identical and placed both as synonyms of *Polyporus biennis*. Saccardo (1925) upholds him in this assumption, and is undoubtedly correct in doing so. Some slight chance of confusion arises, however, when we find that later Bresadola (1931) transferred these synonyms to a position beneath the

rufescent variety. One naturally wonders why this change was made for no reason is given. These both belong, as Bresadola first placed them, among the synonymy of *P. biennis*.

Rea (1922) maintains Fries' early attitude, and considers *Polyporus biennis* a true *Daedalea*. However, we find that he designates it as "*Daedalea biennis* (Bull.) Quél." Fries first described this fungus as a *Daedalea* and later published it as a *Polyporus*. Quélet reversed the action of Fries, and first (1872) concluded the species to be a *Polyporus*. Later (1886) he supported its position as *Daedalea biennis*, and in doing so failed to give Fries due credit. Rea, apparently because of this, was led to believe that Quélet made the original proposal for the use of this name.

There are but two synonyms given by Rea in connection with this species. As these are *Polyporus rufescens* (Pers.) Fries, and *Boletus biennis* Bull., as figured by Sowerby, we must conclude that in his opinion the rufescent form cannot be distinguished from that originally described by Bulliard.

Bresadola (1931) has described and illustrated a fungus purporting to be *Polyporus biennis*. The color of the pileus and stipe is represented as a dirty gray throughout. The pores are shown as large, oval and elongated in the direction of the radius of the cap. They have thick dissepiments. His description is inadequate, and does not apply to either his own colored plate or to the plant as described by Bulliard.

The generally peculiar situation warrants one in assuming that *Polyporus biennis* is not well known in Europe, though supposedly a common fungus. That being the case, it is not surprising that its varieties should also be in a confused state, and even less understood.

2. *Polyporus biennis* (Bull.) Fries, var. *Sowerbei* (Fries) comb. nov.

*Sistotrema rufescens* Pers. Syn. Fung. 550. 1801. In part.

*Daedalea biennis* (Bull.) Fries, var. *Sowerbei* Fries, Syst. Myc. 1: 332. 1821.

*Polyporus rufescens* (Pers.) Fries, Syst. Myc. 1: 351. 1821.

*Daedalea rufescens* (Pers.) Secr. Mycogr. Suisse 2: 483. 1833.

*Polyporus biennis* (Bull.) Fries, var. *rufescens* (Pers.), Bres.  
Ic. Myc. 20: pl. 958. 1931.

Basidiocarp solitary and simple, rarely imbricated, usually stipitate, but occasionally sessile; pileus convex at first, then plane to depressed and infundibuliform, frequently dimidiate, 5–12 cm. broad, 0.5–1.5 cm. thick; surface strigose or tomentose to hispid, rarely subglabrous in age, ferrugineous to rufescent-brown throughout, azonate; margin variable, thin and acute to thick and obtuse, fertile below, reflexed to repand; context white, changing to isabelline or fawn on drying, duplex, with a soft and spongy upper layer, the lower firm and coriaceous, hardening on drying to woody, 0.3–1 cm. thick; tubes of the same color as the upper surface, sometimes slightly lighter, large, sinuate, rarely extremely daedaloid, sometimes quite angular approaching alveolar, very unequal, averaging 21 per sq. cm., decurrent, dissepiments thin, entire, becoming more or less lacerate-dentate in age; stipe lateral to subcentral, occasionally central, rarely wanting, 3.5–4.5 cm. long, 1–1.5 cm. thick, irregular in shape, rugose, subtomentose, concolorous with the surface of the pileus, interior white; basidia elongate-clavate,  $20-30 \times 5-7 \mu$ ; spores ellipsoid to broadly ovoid,  $5-7 \times 3.5-5$  ( $6 \times 4$ )  $\mu$ , hyaline, smooth, apiculate.

TYPE LOCALITY: England.

HABITAT: Fallen and felled timber and tree stumps, rarely on soil from buried wood.

DISTRIBUTION: Europe; Victoria, Queensland and West Australia (Cooke).

ILLUSTRATIONS: Sowerby, Engl. Fungi, pl. 191. 1799; Bresadola, Ic. Myc. 20: pl. 959. 1931. As *Polyporus perennis*.

As already noted there has been much confusion between *Polyporus biennis* and this rufescent variety. Reference to the works of Sowerby, Fries and Persoon would have prevented the present confusion due, apparently, to a sequence of misinterpretations. Sowerby's plant, upon which this variety is based, is very characteristic and readily distinguishable from the species.

The entire surface, in the case of var., *Sowerbei*, is of the same deep reddish-brown color, though in its younger state the pore surface may be of a slightly lighter shade than upper surface or stipe. It should also be noted that, while in *Polyporus biennis* the pores, midway stipe and margin, average 48 to the sq. cm., in number, in var. *Sowerbei* the average is but 21 to the sq. cm. These larger

pores attain this size by being broader in proportion to their length than in the species. They are consequently more or less sinuous, or irregular, and with less of the close labyrinthiform appearance found in the more compact pore surface of *P. biennis*.

Hard (1908) has reported *Polyporus rufescens* as rather common in the vicinity of Chillicothe. While Hard's description is very brief, it seems probable that he had the form which we will consider next and not var. *Sowerbei*. Thus far I have been unable to locate any authentic reports of this variety from North America. References made by Berkeley, Curetis and Lloyd to *P. rufescens* in the United States will also be considered in connection with the next variety.

When Sowerby (1799) issued his plate 191, with a brief note regarding the collection of this fungus in England, he did not consider the plant a new species but distinctly designated it as *Boletus biennis* Bull. Later Fries (1821) transferred Bulliard's *B. biennis* to the genus *Daedalea* and at the same time recognized the form with which Sowerby was dealing as having certain well marked differences. He published a brief description of it under the name *Daedalea biennis* var. *Sowerbei*. Though this will be readily found in Vol. 1, page 332, of the "Systema," I have not seen a single reference to this act anywhere in the mycological literature.

In the meantime Persoon (1801) had published his *Sistotrema rufescens*. At first Fries considered this to be a distinct species and included it, as *Polyporus rufescens*, in the same volume (p. 351) in which he described his var. *Sowerbei*. Sometime later Fries (1874) expressed the opinion that Persoon's *S. rufescens* did not represent one species but several and that it was, in part, his var. *Sowerbei*. Persoon's (1803) plate 6, labeled *S. rufescens*, is definitely referred by Fries to *P. acanthoides*.

Even Fries, however, is not devoid of fault for we find in his "Hymenomycetes Europaei," as a synonym under *Polyporus biennis*, reference to "*Daedalea rufescens* Pers., Myc. Eu. 2: 206." There is no such citation in this publication by Persoon. Reference to Persoon's publication leaves no doubt but that Fries intended to cite the combination *Sistotrema rufescens* Pers. var. *biennis* (Bull.) Pers. Nor is Persoon, at any time, accountable for the combination *D. rufescens*, but rather Secretan.

The description given by Secretan (1833) would seem to indicate, though he refers to plate 6 of Persoon's "Icones pictae," that he was dealing with the form interpreted by Fries as this rufescent variety of *Polyporus biennis*. It seems that Secretan's *Daedalea rufescens* should be considered here and not among the synonymy with *P. acanthoides*.

Bresadola (1931, pl. 958) illustrates a fungus under the name *Polyporus biennis* (Bull.) Fries, var. *rufescens* (Pers.) Bres. Here again we find a fungus with characteristics little suited to the plant intended. What Bresadola had in this case is difficult to say. If, on the other hand, we refer to his plate 959 we find our var. *Sowerbei* well depicted in the lower figure. The central figure appears abnormal as it shows a tendency toward zonation. The upper figure represents our fungus with the central portion of its upper surface abnormal through what is apparently a secondary growth of the hirsute layer. These appear under the name *P. perennis*, which they most decidedly do not represent.

How Bresadola came to misinterpret so common a fungus as *Polyporus perennis* is difficult to understand. He includes *Xanthochrous perennis* (L.) Pat., among his brief synonymy, and this offers a suggestion. It is possible that he was influenced by Patouillard (1898) who divides his new genus *Xanthochrous* into several sections and refers the first of these to "Perennes Fr., Nov. Symb. p. 71." This citation is incorrect and one does not know whether Patouillard intended, when citing Fries (1851), to refer to "Stirps Perennes" of page 55 or the members of "Stirps Coriacea" of page 71. If the latter were his object why does he include *P. perennis* Fries, as an example, and if the former were his idea why do we find the characteristics of the species Fries describes in his "Stirps Coriacea" used in the genus description? The species included on page 71 of Fries' work are of the anoderm type with "contextu tenacei floccoso" and sinuate, daedaloid pores, quite different in character from the well known *P. perennis*.

The first species recognized by Patouillard in his genus *Xanthochrous* is *Trametes Pini* (Thore) Fries, and this, according to our rules, must be considered the type of that genus. His succeeding comments, however, are such as to make it possible to interpret *Polyporus tomentosus* Fries, as the type, as has been done on



occasion. It is obvious that *P. perennis*, has been misinterpreted by Patouillard and Bresadola. The fungus illustrated by Bresadola in his "Iconographia" under that name represents *P. biennis* var. *Sowerbei*.

3. *Polyporus biennis* (Bull.) Fries, var. *distortus* (Schw.) comb. nov.

*Boletus distortus* Schw., Schr. Nat. Ges. Leipzig 1: 97. 1822.

*Polyporus distortus* (Schw.) Fries, Elench. Fung. 1: 79. 1828.

*Polyporus abortivus* Peck, Bot. Gaz. 6: 274. 1881.

*Daedalea abortiva* (Peck) Pat., Essai Tax. Hymén. 96. 1900.

*Daedalea distorta* (Schw.) Pat., Essai Tax. Hymén. 96. 1900.

*Abortiporus distortus* (Schw.) Murr., Bull. Torrey Club 31: 422. 1904.

*Polyporus rufescens* (Pers.) Fries, var. *hexagonoides* Lloyd, Letter 40: 2. 1912.

Basidiocarp variable in form and size, frequently solitary, sometimes subcaespitose through the branching of the stipe near the base, occasionally entirely resupinate; pileus fleshy-tough when fresh, thin, plane or depressed, circular, infundibuliform, or irregular in outline, rarely imbricated, often distorted, 3–13 cm. in diameter, 0.3–1.5 cm. thick; surface white to alutaceous, drying light tan or gray, compactly villous-tomentose, rarely approaching glabrous, azonate; margin variable, frequently thin and acute but sometimes thick and obtuse, sterile or fertile below, undulate or lobed; context white, isabelline to light tan on drying, duplex, soft and fibrillose-spongy above, firm and corky below, 0.2–1 cm. thick, hyphae rarely branched, 4–8  $\mu$  in diam.; tubes decurrent, white, becoming isabelline on drying, rufescent when bruised, 1–6 mm. long, averaging 1–3 per sq. mm., but exceedingly variable, angular to contorted, or irregular, dissepiments thin, entire to dentate; stipe central to excentric or lateral, sometimes wanting, surface white to tan or gray, tomentose, soft on the outside, firm within, up to 6 cm. long, sometimes rudimentary or tuberculate; basidia 4–5  $\mu$  in diameter; cystidia cylindrical, inconspicuous, 5–10  $\mu$  in diameter; spores hyaline, smooth,  $5-7.5 \times 3-5$  ( $6 \times 4$ )  $\mu$ , ellipsoid to broadly ovoid, apiculate.

TYPE LOCALITY: North Carolina.

HABITAT: About stumps, roots, or in humus containing dead and decaying wood of deciduous trees.

DISTRIBUTION: Eastern Canada and United States, south to Louisiana, west to Wisconsin, Missouri and Texas. Also collected in Puerto Rico.

ILLUSTRATIONS: Lloyd, Syn. Stip. Polyp. fig. 456, as *Polyporus rufescens*, and fig. 458. 1912; Myc. Notes 40: fig. 753. 1916; Myc. Notes 69: pl. 236, fig. 2395. 1924, as *P. rufescens*. Overholts, Wash. Univ. Stud. 3: pl. 1, fig. 3, a-b. 1915.

This variety is distinguishable from the preceding by its entirely white or slightly alutaceous pileus and the size of its pores. The pores are usually from 1-3 per sq. mm., and very rarely fewer than 100 per sq. cm., midway stipe and margin. Chlamydospores, 5-8  $\mu$  in diameter, have been reported, and Overholts (1914) says that conidia,  $5.2-7.8 \times 3.3-4.2 \mu$ , ovoid to elliptical, white and smooth, are sometimes present.

In many cases the distorted, teratological form of this variety will be found, and from this condition the name of the fungus has arisen. The normal plant is not uncommon, however, and should be recognized. The percentage of teratological plants is proportionately high, and most descriptions give great weight to these irregularities of the fungus. The plants assume, however, such a variety of form that it is neither necessary nor of value to consider them in detail.

In the matter of color change it seems that rufescent discolorations are largely due to mechanical injury that has affected the surface. This, also, may be the case with plants approaching a somewhat glabrous state. It will be found that when such color changes appear there has developed a definite change in the texture of the tissues involved. Naturally such changes are of ecological rather than phylogenetic significance.

This variety has also had a devious history. Schweinitz (1822) first described his No. 903, collected in North Carolina, as *Boletus distortus*. He accompanied his description with the suggestion of a possible relationship to *Sistotrema biennis*. Later (1832) he reported his No. 476, from North Carolina and Pennsylvania, under the name *Daedalea biennis*, and included his *Boletus distortus* as a synonym. In doing this he refers definitely to his No. 903 of the previous publication so that there can be no doubt he considered both collections as specifically identical, that his

*B. distortus* was not a good species and merely the American representative of the European fungus.

Berkeley and Curtis (1856), with, as they say, "a view to place the Mycology of the United States on a firm and stable foundation," published comments upon a number of Schweinitz's species. Here we find No. 476 designated as *Daedalea biennis*, and it is remarked that this is equivalent to *Polyporus rufescens*. It thus becomes evident that Berkeley and Curtis considered *D. biennis*, *P. rufescens* and *Boletus distortus* as botanically identical.

Berkeley (1872) again discusses several American collections deposited in the British Museum. These include four from North Carolina, collected by Curtis, and one from Pennsylvania, collected by Michener. These are designated as *Polyporus rufescens*. From the field notes of M. A. Curtis accompanying these specimens, a bound, typewritten copy of which is in the library of the New York Botanical Garden, it seems that Curtis also considered these as *P. rufescens*. Two of the numbers, according to these notes, are decidedly of the *distortus* form.

Patouillard (1900) also creates an interesting situation with regard to this variety. In the first place he recognizes both *P. abortivus* Peck, and *P. distortus* (Schw.) Fries, as distinct species, and removes them to a genus which he designates as "*Daedalea* Pers., Synops. p. 449." "Le type de ce petit groupe," he says, "est le *Daedalea biennis* Pers." Persoon (1801) discusses the genus *Omphalia* on page 449 of his "Synopsis." The genus *Daedalea* is described on page 499 with *D. quercina* as the type. There is no such fungus as *D. biennis* Pers., and neither is *D. biennis* (Bull.) Fries, nor any of the species Patouillard places in the genus "*Daedalea* Pers.," at this time, included under that generic name by Persoon. It should also be noted that none of the species included in *Daedalea* by Persoon are mentioned as belonging there by Patouillard.

Murrill (1904) established the new genus *Abortiporus* for the reception of *Boletus distortus*. The need for this genus has been seriously doubted, and it has remained with but two possible species to its credit, the present variety and that considered last in this paper. Murrill recognized that *P. distortus* had been badly

confused with *P. rufescens*, and says that a study of these forms in the field shows a very marked difference. He makes no allusion to a possible relationship with *P. biennis*.

Lloyd (1912) says that *Polyporus distortus* is a frequent plant in the United States, and that he believes it to be only a distorted form of *P. rufescens*. In fact he is so inclusive as to suggest that the form illustrated by Sowerby in his plate 191, Persoon's "Icones pictae" plate 6 [*P. acanthoides*], *P. rufescens*, *P. distortus*, and *P. heteroporus* are in reality all the same species. Two years later Lloyd (1914) declares that *P. biennis* and *P. rufescens* are synonymous. He makes no effort to discriminate, with regard to pore character and pileus coloration, between the normal American variety and its European relatives. I have examined specimens determined by Lloyd, and the only conclusion one can arrive at is that he based his interpretations upon those Berkeley and Curtis had already made with respect to American material, and not on any familiarity with European specimens of either *P. biennis* or its variety *Sowerbei*.

In spite of his inclusive synonymy Lloyd (1912 b) describes a fungus, with the same general characteristics but having large, round, shallow pores, as a new variety. He says that the upper surface of this fungus is not brown, but light colored and not distinctly pubescent. None of our normal American material is brown. This variety would seem to be based on a specimen that had matured with abnormal rapidity and lacking, as a consequence, the usual type of tissue and pore development. Lloyd, though usually quite critical, named this round-pored variation *P. rufescens* var. *hexagonoides*.

Among the later American mycologists the tendency is to maintain *Polyporus distortus* (Schw.) Fries, as a distinct species. Overholts (1914, 1915, 1933), Neuman (1914), Dodge (1914) and Lowe (1934) do not consider the possibility of a relationship between *P. distortus* and the European *P. biennis*. It seems better to me, in this case, to confess a relationship than to contend for autonomy. Specific integrity is based upon the teratological form while the very evident relationship is based upon the normally developed fungus.

4. *Polyporus biennis* (Bull.) Fries, var. *Ballouii* (Lloyd)  
comb. nov.

*Polyporus rufescens* (Pers.) Fries, forma *Ballouii* Lloyd, Letter  
49: 10. 1914.

*Polyporus Ballouii* Lloyd, Letter 58: 7. 1915.

Basidiocarp variable in form, frequently solitary, stipitate, sub-stipitate or sessile, sometimes resupinate; pileus fleshy-tough when fresh, somewhat coriaceous on drying, thin, plane, depressed or infundibuliform, circular or irregular in outline, sometimes imbricated, often much distorted, 2-10 cm. in diameter, 0.2-1 cm. thick; surface white to alutaceous, drying light tan or gray, compactly villose-tomentose, rarely approaching glabrous, azonate; margin variable, thin, usually fertile below, undulate or lobed; context white when fresh, drying isabelline to light tan, duplex, soft and fibrillose-spongy above, firm and corky below, 0.1-0.5 cm. thick; tubes decurrent, white, becoming isabelline on drying, rufescent when bruised, averaging 3-5 per sq. mm., angular to contorted, or irregular, rarely approaching circular, dissepiments thin, usually entire; stipe central to excentric or lateral, sometimes wanting, surface white, tomentose, soft on the outside, firm and leathery within, sometimes rudimentary or lacking; spores hyaline, smooth,  $5-7 \times 3-5$  ( $6 \times 4$ )  $\mu$ , ellipsoid to broadly ovoid, apiculate, with a single guttation.

TYPE LOCALITY: New York.

HABITAT: About tree stumps, roots and in humus containing decaying wood of deciduous trees.

DISTRIBUTION: New York and Ohio.

ILLUSTRATIONS: Lloyd, Myc. Notes 69: pl. 236, fig. 2395, 2396. 1923.

Our var. *Ballouii* differs from var. *distortus* in the thinner and more leathery nature of its pileus, the smaller size of its pores and a somewhat greater range of spore size. The plant is usually smaller than the preceding variety. In this connection, however, it should be noted that the size of the plant which Lloyd (1923) figures is as large as that frequently attained by var. *distortus*, and helps fix this as a distinct variety by removing any prejudice toward the idea that var. *Ballouii* is merely a juvenile form.

Rufescent discoloration, it should be recognized, occurs frequently when this plant develops in an abnormal manner. A semi-

glabrous condition of the upper surface is often associated with a similar teratological state.

Lloyd (1914 b), in his first description of this fungus, designates it as forma *Ballouii*, and suggests that it is a variation of *Polyporus rufescens*, or possibly of *P. biennis*. Later (1915) he concludes that it is the same as Murrill's *Abortiporus tropicalis*, but that the name he has proposed is more appropriate and uses it in the specific sense.

Lloyd's descriptions are quite brief, and I have found it necessary to add a number of details. This makes more evident the relationship and differences between this variety and *Polyporus biennis*. As I see the situation, var. *Ballouii* is intermediate between *P. biennis* var. *distortus* and the next variety to be considered, with, possibly, a slightly closer affinity with the former.

5. *Polyporus biennis* (Bull.) Fries, var. *tropicalis* (Murr.)  
comb. nov.

*Abortiporus tropicalis* Murr., Mycologia 2: 185. 1910.

*Polyporus tropicalis* (Murr.) Sacc. & Trott., Syll. Fung. 21:  
277. 1912.

Basidiocarp variable in form, most often solitary, stipitate, sub-stipitate or sessile, sometimes resupinate, rarely imbricated or sub-caespitose through the branching of the stipe near the base; pileus spatulate to reniform when of lateral growth, subspatulate, circular, plane, depressed to infundibuliform when growing upright, sometimes much distorted, fleshy-tough when fresh, flexible, more rigid when dry, thin,  $1-2 \times 2.5-3$  cm. in length and breadth,  $0.2-0.4$  cm. thick; surface white to alutaceous, drying light tan or gray, finely tomentose, spongy, azonate; margin usually thin, undulate to lobed, sterile or fertile below; context white, isabelline or light tan on drying, duplex, soft and fibrillose-spongy above, firm and corky below; tubes decurrent, white, short, mouths minute, averaging 10-12 per sq. mm. glistening when fresh. dissepiments firm, obtuse to subacute, entire; stipe sometimes central, more often excentric, lateral or wanting, expanding into the pileus, irregular, up to 3 cm. long and 5-10 mm. thick, tomentose, soft on the outside, firm within; spores hyaline, smooth, ellipsoid to broadly ovoid,  $4-7 \times 2-6$  ( $6 \times 4$ )  $\mu$ , apiculate.

TYPE LOCALITY: Jamaica.

HABITAT: Stumps and roots of deciduous trees.

DISTRIBUTION: West Indies, Mexico and South America.

The spores of this variety show an even greater range in size than do those of the preceding. The pores are exceedingly small, and difficult to see when in the young, fresh state they, and the relatively thick dissepiments, are covered with a profusion of spores. This condition results in what is apparently a smooth, glistening surface. Spore production is exceedingly luxuriant for the size of the fungus. The pores are so small that they have lost all vestige of the daedaloid condition that is typical of *Polyporus biennis*.

#### KEY TO POLYPORUS BIENNIS AND VARIETIES

Characteristics in common: Basidiocarp simple to imbricate from a short stipe, or sessile; pileus convex, plane to depressed; surface tomentose to strigose, azonate; context white when fresh, duplex, upper layer spongy, lower firm and coriaceous; tubes decurrent; stipe subcentral to lateral; spores ellipsoid to broadly ovoid,  $4-7.5 \times 2-6$  ( $6 \times 4$ )  $\mu$ , hyaline, smooth, apiculate.

1. Pilear surface colored .....2.
1. Pilear surface white to alutaceous, colored or blotched rufescent only in teratological material .....3.
2. Upper surface flesh-colored to light reddish-brown in the center with wide white margin, scurfy-tomentose to strigose; tubes white, labyrinthiform or sinuate, 48 per sq. cm. ...1. *Polyporus biennis*.
2. Entire surface ferrugineous to rufescent-brown, upper strigose or tomentose to hispid; tubes sinuate to angular, 21 per sq. cm.  
2. var. *Sowerbei*.
3. Tubes 1-3 per sq. mm. white, angular, contorted or irregular; upper pilear surface compactly villose-tomentose .....3. var. *distortus*.
3. Tubes smaller than 1-3 per sq. mm. white .....4.
4. Tubes 3-5 per sq. mm. angular to irregular, sometimes contorted; upper pilear surface compactly villose-tomentose  
4. var. *Ballouii*.
4. Tubes 10-12 per sq. mm. round to angular, upper pilear surface finely tomentose .....5. var. *tropicalis*.

The above key is prefixed with a brief statement of characters held in common in order to present not alone differences but to emphasize the undoubted relationship of these fungi. While pore size and shape pass through a definite and consistent evolution, it should be noted that spore form remains unchanged. Though these have a fairly wide size range they are typically  $6 \times 4 \mu$ . Cognizance should be taken of the over emphasis placed upon teratological characters in previously published descriptions of sev-

eral varieties included here. The var. *Sowerbei* is naturally of a rufescent color throughout, while *Polyporus biennis*, and its other three varieties, only assume such coloration upon mechanical injury or the presence of other teratological conditions.

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# THE PERFECT STAGE OF BOTRYTIS CINEREA<sup>1</sup>

J. W. GROVES<sup>2</sup> AND F. L. DRAYTON<sup>3</sup>

(WITH 1 FIGURE)

In the genus *Botrytis*, a number of species with well defined characters have been described and named, but one of the oldest specific names, *B. cinerea* Pers., has been applied to a loosely defined group of fungi, which develop the well known grayish-brown conidiophores and conidia, and large, black, flat sclerotia adhering closely to the substratum. Such forms are found on a great many plants, exhibiting various degrees of pathogenicity or living as saprophytes. Their common occurrence, widespread distribution, and often destructive effects have made them the subject of much investigation and a voluminous literature has grown up dealing with their parasitism, host range, physiology, and cytology.

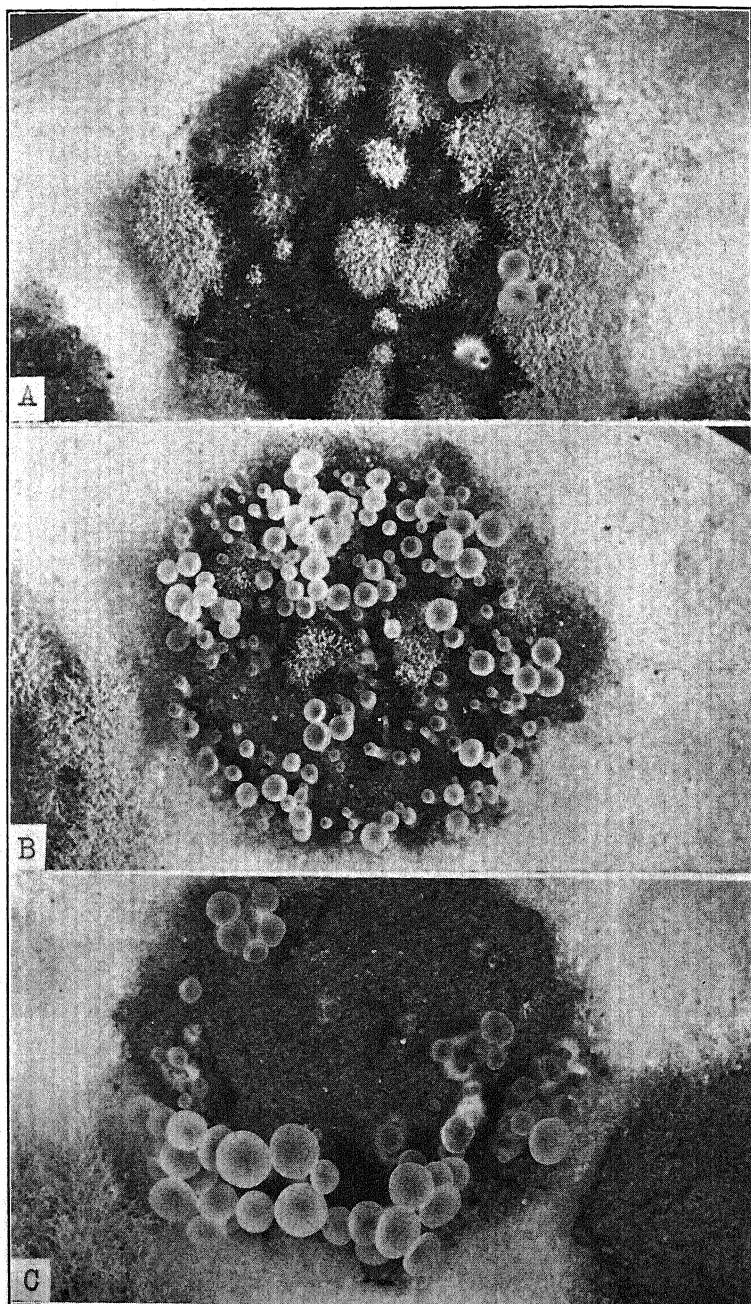
When these *Botrytis* forms are isolated, the cultures show an extraordinary range of variability in the production of sclerotia, appressoria, and conidia, in the rate of growth, and in the amount of aerial mycelium. In general, however, there is no option but to assign all these forms to the inadequately delimited species, *B. cinerea* Pers. and in the more recent literature one generally finds them regarded as a group, with each form being referred to as a *Botrytis* of the *cinerea* type.

The literature concerning the genetic connection of species of the genera *Botrytis* and *Sclerotinia* has been reviewed by Drayton (1937). Since this was written a *Sclerotinia* stage has been established by Gregory (1938) for *B. polyblastis* Dowson. Of the five recorded cases in which a genetic connection has been demonstrated by means of cultural technique, three of them, namely, *S. Ricini* Godfrey, *S. Porri* van Beyma Thoe Kingma, and *S. con-*

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*voluta* Drayton, have conidial stages of the *B. cinerea* type, while in *S. polyblastis* Gregory and *S. Geranii* Seaver and Horne, the conidia are quite distinct. In the three species of the *cinerea* type, the sclerotia and conidia are sufficiently characteristic to warrant specific separation from the large number of more closely related and intergrading forms with which every plant pathologist and mycologist is familiar. In the latter group, we have succeeded in developing, in certain isolates, a sexual stage belonging to the genus *Sclerotinia*.

For several years the junior author has been accumulating a collection of cultures of *B. cinerea* types. In this collection there were about seventy isolates from various hosts and localities and these were used in the attempts to obtain a perfect stage. In the first trial, the cultures were divided arbitrarily without regard to host, into eight groups, according to the gross appearance of the cultures. Representatives of each group were chosen and were cross-spermatized with members of other groups. No apothecia were obtained in this first experiment, but apothecial fundaments, which failed to mature, were observed in some isolates from apples and celery from cold storage and from potato plants collected in the field. In the next experiment all the available isolates from these three hosts, sixteen in all, were used, and from nine, mature apothecia were obtained.

The technique described by Drayton (1937) for the production of apothecia of *Sclerotinia convoluta* was followed, but with a few modifications. Spermatization was delayed until two weeks after the cultures had been moved from 0° to 5° C. and they were then put at 14° C. for one month prior to their transfer to the greenhouse. Two methods of spermatization were used. In the first, the spermatial suspension was applied directly to the sclerotia as described for *S. convoluta*. In the second, the suspension was used to moisten sterilized soil, which was then placed over the sclerotia. Apothecia were obtained with both methods, but the second was deemed preferable, because the soil helped to prevent

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FIG. 1. Apothecia developed in culture from isolates of *Botrytis cinerea*. A, from apples in storage; B, from potato stems collected in the field; C, from celery in storage. Note the association of conidia and apothecia ( $\times 1.5$ ).

excessive drying and also reduced conidial production. In addition, it was found that exposure to direct sunlight seemed to be harmful and better results were obtained when the cultures in the greenhouse were exposed only to north light.

On April 7, about 2 weeks after the cultures were moved to the greenhouse, the first mature apothecium was found. This was followed by the development of a great many more apothecia during the subsequent 6 weeks, after which the experiment was abandoned because of the high temperature in the greenhouse. Figures 1 to 3 illustrate some of the apothecia, with the accompanying conidiophores and conidia, obtained from isolates from the three host plants mentioned above.

The apothecia from the nine isolates discharged ascospores and about 20 single ascospore cultures were obtained from each isolate. In certain isolates the single ascospore cultures were uniform in their rate of growth, sclerotial production, and general appearance. In others, very marked differences were observed. Some of the cultures grew rapidly, producing a fluffy aerial mycelium, macroconidia, and eventually sclerotia, while others grew very slowly, forming a white, silky, aerial mycelium and never producing macroconidia or sclerotia, in fact they presented the appearance of cultures which we would ordinarily consider as staled. In most cases the cultures which did not produce sclerotia, developed abundant spermatia, but none has been observed in which a sclerotium-producing culture failed to produce spermatia.

The variation in the cultures obtained from single ascospores of the nine isolates cannot be explained from this experiment. The original isolations were made from conidia and sclerotia and it has been shown by Hansen and Smith (1932) that the conidia and hyphal cells of *B. cinerea* are multinucleate and that interchange of nuclei can take place by hyphal anastomoses. There could be no certainty therefore, that an isolate obtained in this way would possess nuclei of the same genetic constitution. In the single ascospore cultures, however, it can be assumed that all of the nuclei in each culture are of the same genetic constitution, thus providing homozygous material for experimentation.

The taxonomic significance of the development of sclerotinioid apothecia by some of the common forms of *B. cinerea* cannot be

properly evaluated at the present time, hence no change in nomenclature is proposed. Certain morphological differences are evident in the apothecia obtained and it is possible that there may be more than one species involved even in the comparatively few isolates used. The work now in progress with the cultures of single ascospore origin will, no doubt, give some clue to the interpretation of the numerous variations observed and help to clarify the species concept in this perplexing group of fungi.

DIVISION OF BOTANY AND PLANT PATHOLOGY,  
CENTRAL EXPERIMENTAL FARM,  
OTTAWA, CANADA

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## TWO NEW SPECIES OF RUSSULA TO- GETHER WITH THE SPORE ORNA- MENTATION OF SOME OF OUR AMERICAN RUSSULAS

GERTRUDE S. BURLINGHAM

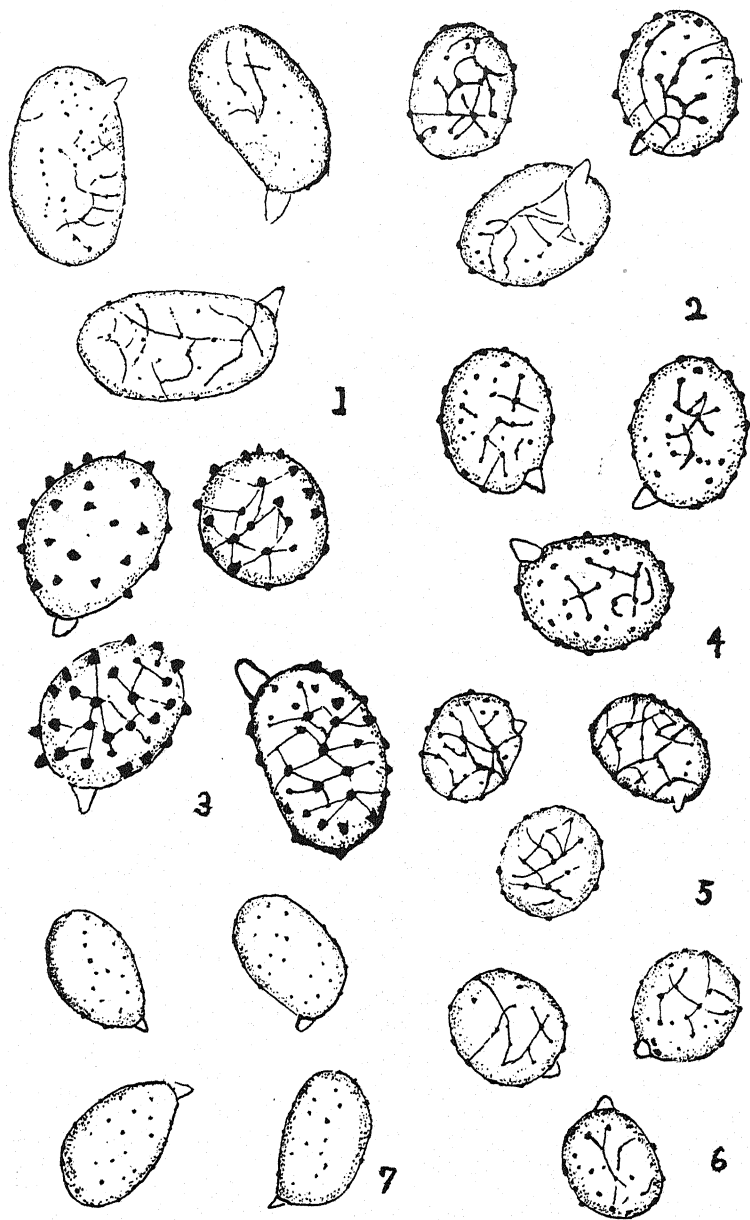
(WITH FOURTEEN FIGURES)

It is a great pleasure to find a species of *Russula* with some distinctive characteristic which makes its identification easy and positive. Such was a red *Russula* collected near Longwood, Florida, in November 1935. In the field, however, it appeared to be a common species, but when the spores were examined under the oil immersion with an iodine stain, they were found to be similar to the spores of *Russula heterospora* described by H. C. Beardslee in *Mycologia* 26: 259. 1934. Since my first collection the weather conditions have not been right for the growth of the species during the fall season until this November of 1938 when following warm rainy weather it again appeared in the same woods and I was able to obtain a photograph. The species grows in the same woods where Mr. Beardslee found the type specimens of *Russula heterospora*. Since Mr. Beardslee kindly gave me access to his choice collecting grounds, and in recognition of his extensive work on this genus, I have chosen this specific name.

### *Russula Beardslei* sp. nov. (FIG. 1, 10).

Pileus peach red,<sup>1</sup> sometimes fading to incarnate on the margin, glabrous, viscid when wet, with cuticle separable on the edge, up to 8 cm. broad; margin becoming obscurely striate-tuberculate; context white except tinted red next the surface of the pileus, unchanging, bad tasting then slowly peppery, no special odor; lamellae fleshy-white tone 4 singly, a few scattered incomplete ones, some forking next the stipe but mostly simple, broad, rounded near the stipe then attached by a decurrent tooth; stipe white, firm becoming spongy, nearly equal except spreading at the apex and rounded off at the base, 6 cm.  $\times$  1.5-1.8 cm.; spores

<sup>1</sup> Repertoire de Couleurs.



FIGS. 1-7. Spore markings of some American russulas. 1, *R. Beardslei*; 2, *R. insignita*; 3, *R. Ballouii*; 4, *R. corallina*; 5, *R. blanda*; 6, *R. flocculosa*; 7, *R. ventricosipes*.



honey yellow tone 1 in. thick mass,  $6.25-6.87 \mu \times 10-12 \mu$  with very minute protuberances arranged in lines or with fine connecting lines, apiculate, unsymmetrical.

Pileo rubro, jove pluvio viscido, pellicula subseparabile, margine demum striato; lamellis pallidis, simplicibus, subaequalibus, proxime stipitem leviter rotundatis et adnectis decurrente dente; stipite albo, 6 cm.  $\times$  1.5-1.8 cm.; carne albo, sapore male dein tarde acri; sporis melleis,  $6.25-6.87 \mu \times 10-12 \mu$ .

TYPE LOCALITY: Longwood, Florida.

HABITAT: On the ground in sandy soil in live oak woods.

While having the same elongated spores noted in *Russula heterospora* it differs in the color of the spores, the taste of the

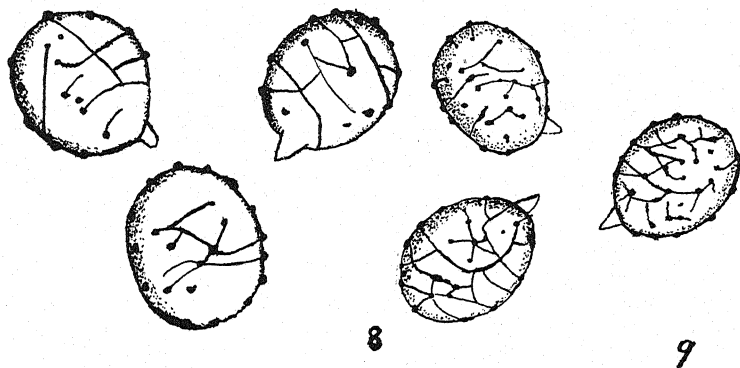


FIG. 8, spores of *R. astringens*; 9, spores of *R. admirabilis*.

context, the color of the pileus, and the practically simple lamellae.

The following species has been found for several years by Mr. Beardslee growing on a lawn near Longwood, Florida, and it has occurred rather abundantly after rains each year since I have been collecting in this locality.

*Russula admirabilis* sp. nov. Beards. & Burl. (FIG. 9, 11).

Pileus rather firm, broadly convex becoming centrally depressed, coppery red tone 1-4, or old blood red, with the central area pale flesh to pale ecru or sometimes nearly white, densely pruinose at first, sometimes becoming pruinose-granular, viscid when wet, cuticle separable up to the disc, 4.2 cm. to 8 cm. in diameter; margin even becoming obscurely striate-tuberculate on the extreme edge; context white, unchanging, mild without special odor; lamellae pure white at first, becoming pale ecru 66 tone 4, equal, broad, simple, rounded on approaching the stipe and depressed,

then narrowly attached; stipe white, nearly equal, rather firm to spongy with maturity, 3.5 cm.  $\times$  1–1.5 cm.; spores honey yellow 35 tone 2,  $6.5 \mu \times 8\text{--}8.75 \mu$ , reticulate with small protuberances of different sizes connected by fine bands and lines, apiculate and unsymmetrical.

Pileo firmulo, e convexo depresso, cupro-rubro margine, disco pallido, primo pruinoso, jove udo viscido; margine laevi, exoleto striatulo, 4.2 cm. to 8 cm.; carne albo, miti; lamellis ex albo pallidis, aequalibus, simplicibus, postice rotundatis; stipite albo firmulo curto; sporis melleis, reticulatis,  $6.5 \mu \times 8\text{--}8.75 \mu$ .

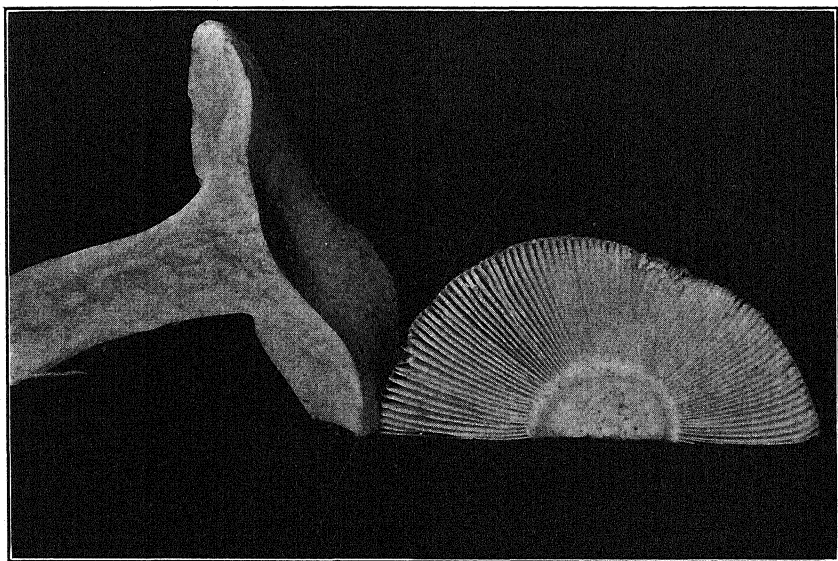


FIG. 10. *Russula Beardslei*, No. 7—Nov. 16, 1938.  $\frac{3}{4}$  natural size.

TYPE LOCALITY: Longwood, Florida.

HABITAT: In grass on a lawn with scattered trees of *Pinus palustris* near.

The stipe is so short that the pileus sets close to the ground. The incarnate to coppery red margin and pallid center, mild taste and white lamellae becoming only pale ecru will serve to distinguish it in the field; while the spore color and markings will clearly separate it from *Russula rosea* Quél. and *Russula lutea* var. *armeniaca* (Cooke) Rea or *Russula chamaeleontina* Fries, or *Russula amygdaloides* Kauff. From *Russula aurora* Krombh. it dif-

fers in the persistently mild taste, simple lamellae, smaller size, separable pellicle, and shape and size of the spores.

Much confusion has arisen in the genus *Russula* because of the failure to give in the type description the color of the spores as based upon a dense spore print. In addition to the spore color so obtained, a camera lucida drawing of spores treated with the iodine solution recommended by Crawshay<sup>2</sup> should accompany every original description, since the spore ornamentation is often the final means of identification. Because of this importance of the spore markings, and in view of the fact that all of our species de-

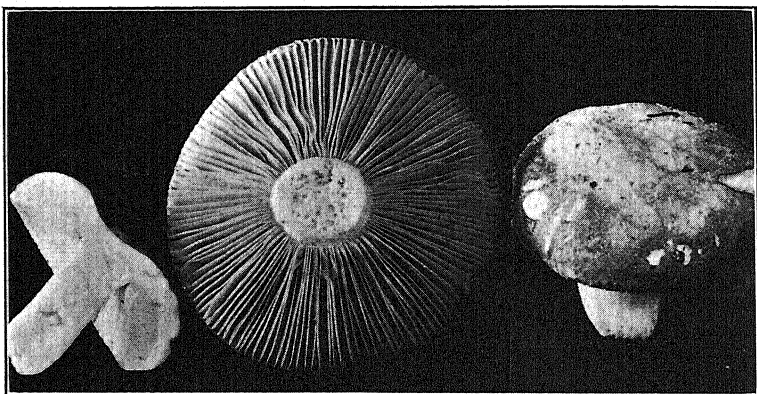


FIG. 11. *Russula admirabilis*, type. Natural size.

scribed prior to the last few years have lacked drawings of the spore ornamentation as brought out with the iodine stain, I have undertaken to make a series of plates showing the spore ornamentation of our American species of *Russula*, using spores from the type collection wherever possible. If photographs of a species have never been published, they will be included if available.

The photograph of *Russula ventricosipes* Peck was taken from specimens found at Yarmouthport, Cape Cod, Mass., under pines. The species has a superficial resemblance to *Russula foetens* Fries. Specimens were found growing in abundance, the pileus reaching a diameter of from 12 to 15 cm. in diameter. When not bruised in coming through the sand, the stipe would be nearly white, but

<sup>2</sup> Spore Ornamentation of the Russulas, p. 72.

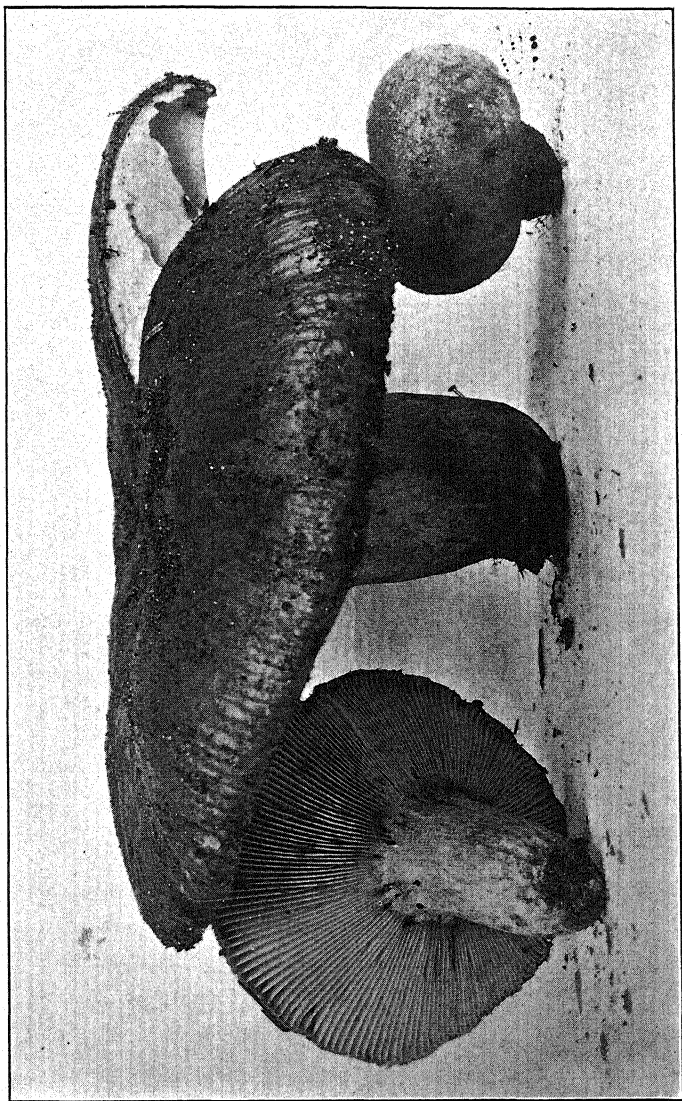


FIG. 12. *Russula ventricosipes* Peck. Natural size.



FIG. 13. *Russula astrungens* Burl.  $\frac{2}{3}$  natural size.

otherwise or where handled the stipe became red due apparently to an exudation from glandular like dots. While stout the stipe is comparatively short. The spores are very distinctive, as shown in figure 7.

The photograph of *Russula astringens* Burl. was made from specimens growing on Newfane Hill, Vermont. The species is rather common along wooded roadside under white birches or in deciduous woods containing white birches. *Russula Ballouii* was photographed from specimens collected with W. H. Ballou from the type locality on Staten Island, N. Y.

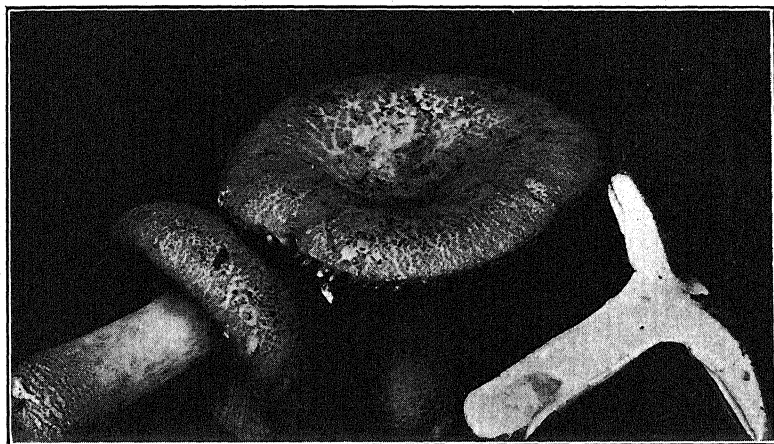


FIG. 14. *Russula Ballouii* Peck. Natural size.

***Russula insignita* nom. nov.**

In North American Flora 9: 212. 1915, I described a new species of *Russula* under the name of *Russula insignis*. Since then I have learned that Quélet had applied that name to another species of *Russula* (Ass. FR. 1887), and it becomes necessary to give another name to my species. In addition to the localities where Mr. Simon Davis collected it, I have found it growing on the grounds of Wellesley College, Mass. This species differs from *Russula farinipes* Rom. in the mild taste, more even margin, and the difference in size, shape and markings of the spores. It does not seem to be related to the Pectinatae group.

## EXPLANATION OF FIGURES

FIG. 1. Spores of *Russula Beardslei*;  $6.25\text{--}6.87\ \mu \times 10\text{--}12\ \mu$  with very minute protuberances arranged in lines or connected by fine lines, apiculate and unsymmetrical.

FIG. 2. Spores of *Russula insignita*, drawn from type;  $6\text{--}6.87\ \mu \times 7.5\text{--}8\ \mu$  exclusive of apiculus, with small protuberances of different sizes, some connected by fine lines, apiculate and unsymmetrical.

FIG. 3. Spores of *Russula Ballouii* Peck;  $7\text{--}8\ \mu \times 8\text{--}10\ \mu$ , rarely  $10\ \mu$ . Under  $\frac{1}{6}$  power they appear echinulate. At first under the oil immersion stained with iodine they appear only echinulate, but when the iodine is washed out, very fine lines like spider's web show connecting some of the spines.

FIG. 4. Spores of *Russula corallina* Burl. from the type;  $6.25\text{--}7\ \mu \times 7.5\text{--}8.7\ \mu$  with small tubercles of different sizes, some connected by fine lines, apiculate and unsymmetrical.

FIG. 5. Spores of *Russula blanda* Burl. from the type; the measurement of the spores at this time gives a smaller size than when fresh,  $5\text{--}6.25\ \mu \times 6.25\text{--}7.5\ \mu$  with small protuberances, many connected by fine lines.

FIG. 6. Spores of *Russula flocculosa* Burl. from the type;  $5\text{--}6.25\ \mu \times 6.25\text{--}6.87\ \mu$ , nearly globose with very small protuberances, some of which are connected by fine lines, apiculate and somewhat unsymmetrical.

FIG. 7. Spores of *Russula ventricosipes* Peck;  $5\text{--}6.25\ \mu \times 8\text{--}10\ \mu$ , apparently smooth without the iodine stain, but with it very minute granular-like protuberances appear, apiculate and unsymmetrical.

FIG. 8. Spores of *Russula astringens* Burl.;  $5\text{--}6\ \mu \times 7\text{--}8\ \mu$ . These spores were drawn on a larger scale than those in the other figures. A few scattered protuberances occur, some connected by fine lines, apiculate and somewhat unsymmetrical.

FIG. 9. Spores of *Russula admirabilis* Beards. and Burl.;  $6.5\ \mu \times 8\text{--}8.75\ \mu$  with scattered small tubercles connected by lines, apiculate and somewhat unsymmetrical.

FIG. 10. *Russula Beardslei*. No. 7. Nov. 16, 1938.  $\frac{6}{7}$  natural size.

FIG. 11. *Russula admirabilis*. Type. Natural size.

FIG. 12. *Russula ventricosipes* Peck. Natural size.

FIG. 13. *Russula astringens* Burl.  $\frac{2}{3}$  natural size.

FIG. 14. *Russula Ballouii* Peck. Natural size.

## PHOTOGRAPHS AND DESCRIPTIONS OF CUP-FUNGI—XXXIII. A NEW BOUDIERA

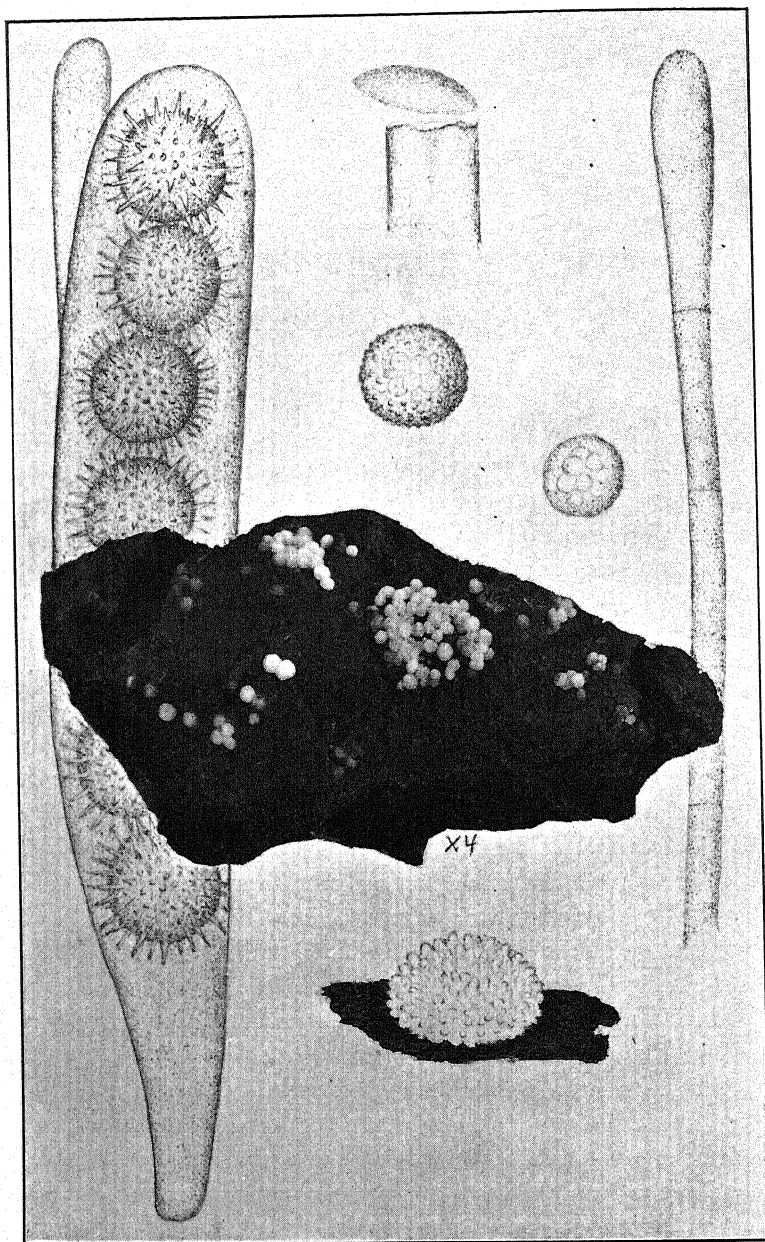
FRED J. SEAVER

(WITH 1 FIGURE)

The genus *Boudiera* was established by M. C. Cooke in 1877, the type species being *Boudiera areolata* Cooke & Phillips, described from material collected in North Wales. The name *areolata* was misleading, since the spores are echinulate rather than areolate. Little seems to have been known of this genus until the writer in 1904 collected in abundance a species in Iowa which is similar if not identical with the European *Boudiera areolata*. This was erroneously described as a *Sphaerosoma* owing to the fact that *Boudiera areolata* had been misinterpreted and misrepresented in the records which were at that time available. Not until 1914, through the examination of an authentic specimen, was the writer able to determine the true characters of the genus *Boudiera*. When this was done it was found that *Sphaerosoma echinulatum* of the writer was only another form of *Boudiera*, so closely resembling the type species that it is even doubtful if the two are distinct, but since there are certain gross characters which appear to differ the two species have been retained in our recent monograph of the operculate cup-fungi.

Recently the writer has received from Dr. Leva B. Walker of Nebraska a beautiful specimen which is unquestionably a *Boudiera*. While the general characters leave no question as to its generic identity, its specific characters differ greatly from the other two described species. The apothecia of *Boudiera areolata* attain a diameter of 5–8 mm. and were dark-brown in color, while the present species from Nebraska is scarcely a mm. in diameter and pure white. Both are characterized by the strongly protruding asci and paraphyses which give to the convex subhemispherical hymenium a much roughened appearance. Apothecia of the Nebraska mate-



FIG. 1. *Boudiera Walkerae*.

rial appear as minute white cushions, as shown in the accompanying photograph. The asci are only half as long as those in *Boudiera echinulata*, but the spores themselves are almost identical except that they are possibly a trifle smaller. In general characters the present species is so distinct from the two formerly described that it must be regarded as new to science.

The present species is dedicated to the collector, who found these beautiful plants growing on a pan of soil on which she was testing the growth of some other organism. There was one large group, as shown in accompanying photograph. The fungus according to the collector, did not continue to reappear, but gradually disappeared soon after the collection of these specimens.

***Boudiera Walkerae* sp. nov.**

Apothecia gregarious, sessile, at first subdiscoïd soon expanding and becoming rounded and cushion-like with the ends of the huge asci protruding and giving the surface roughened appearance, entirely white reaching a diameter of 1 mm.; asci clavate, reaching a length of  $225\ \mu$  and a diameter of  $40\ \mu$ , 8-spored; spores at first irregularly disposed, finally becoming 1-seriate, at first smooth and filled with large oil drops, the surface gradually becoming roughened, the roughenings finally assuming the form of long spines, reaching a diameter of  $25\text{--}30\ \mu$  including spines, or  $18\text{--}20\ \mu$  exclusive of spines, hyaline; paraphyses clavate reaching a diameter of  $15\ \mu$ .

Apotheciis gregariis sessilibus demum convex-hemisphaericis, albidis 1 mm diam.; ascis clavatis,  $225 \times 40\ \mu$ ; octosporis; sporiis demum monostichis perfecte sphaericis initio levibus, pluriguttulatis demum spinulosis, hyalinis,  $25\text{--}30\ \mu$  diam.; paraphysibus clavatis, hyalinis,  $15\ \mu$  diam.

On bare soil in the laboratory.

TYPE LOCALITY: Lincoln, Nebraska.

DISTRIBUTION: Known only from the type locality.

In this species the asci open by means of an operculum, characteristic of the group. After the discharge of the spores the asci themselves partially collapse while the operculum seems to keep approximately its original size; so that the lid of the emptied asci appears to be too large for the ascus, as indicated in the sketch. This is just the reverse of conditions found in some of the other operculates in which the lid is very much smaller than the diameter of the ascus, even after the spores are discharged.

## NOTES AND BRIEF ARTICLES

### NEW SPECIES OF TAPHRINA

In a recent paper (Jour. Wash. Acad. Sci. 29: 222-230. 1939) Dr. Anna E. Jenkins of the Bureau of Plant Industry, Washington, D. C., has described two new species of *Taphrina* on native North American maples under the names *Taphrina Dearnessii* and *Taphrina Carveri*. Dr. Jenkins is expected to write the Exoascales for North American Flora, and this article is another contribution to our knowledge of this group.—FRED J. SEAVER.

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### FLORA AGARICINA DANICA

Volume 4 of this superb work has recently appeared. In this volume the following genera are treated, with the number of species and varieties indicated in parentheses: *Flammula*, (14); *Naucoria* (31); *Tubaria* (7); *Galera* (30); *Bolbitius* (1); *Pluteolus* (2); *Crepidotus* (7); *Paxillopsis* (6); *Paxillus* (4); *Psalliota* (19); *Stropharia* (23); *Lacrymaria* (4); *Hypholoma* (15); *Psilocybe* (12); *Panaeolus* (9); *Psathyra* (30); *Pseudocoprinus* (2); *Coprinus* (35). This volume is illustrated with 39 plates, each containing many figures in color.—FRED J. SEAVER.

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### LICHENS OF THE ANTARCTIC

A report of the "Lichens and Lichen Parasites" of the Second Byrd Antarctic Expedition is published in the Annals of the Missouri Botanical Garden (25: 515-727). The work has been prepared by Dr. Carroll W. Dodge, Mycologist to the Missouri Botanical Garden, and Professor in the Henry Shaw School of Botany of Washington University, and Dr. Gladys E. Baker, Instructor in Botany, Hunter College, and formerly Research Assistant, Henry Shaw School of Botany of Washington University, and has been accomplished with the coöperation of the Botany

Department of the University of Iowa. More than 80 new species are described in this extensive contribution, and these are illustrated in 27 plates, containing 431 figures. This is the largest contribution ever made to the lichen flora of the Antarctic.—FRED J. SEAVER.

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#### GNOMONIA ULMEA

We have recently received a copy of Contributions de l'Institut Botanique de l'Université de Montréal. No. 3. pp. 1-139. Pls. i-xxx. 1938. "Recherches sur le *Gnomonia ulmea* (Schw.) Thüm." by Dr. René Pomerleau.

Dr. Pomerleau's studies are included under three heads: The Biology, Ecology, and Cytology of the elm leaf fungus *Gnomonia ulmea*. This work constitutes the most extensive study yet made of this parasite of the elm. The fungus is endemic in America and according to the author has not yet been found in Europe or Asia. A very detailed study has been made of the life history of the organisms and the method of dissemination and germination of the ascospores, the steps in primary infection, the production and dissemination of conidia and secondary infection by these conidia. The cytological observations include a study of the mycelium, the development of acervuli and the stromata. Having been a former student of the celebrated Prof. Dangeard of Paris, Dr. Pomerleau would naturally be inclined to give special attention to the origin and development of the perithecium. In all, 22 plates are given over to illustrations of various stages in the development of the fungus. He finds only one nuclear fusion and only one reduction. The author concludes as a result of his studies that the ascomycetes are a monophyletic group.—B. O. DODGE.

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#### MICHIGAN MUSHROOMS

A manual of the "Common edible and poisonous mushrooms of southeastern Michigan" has recently been issued by the Cranbrook Institute of Science. The manual has been prepared by Dr. Alexander H. Smith of the University of Michigan, and is designed to supply a local demand, but need not be restricted to local use for

it is suited to the needs of amateur mycophagists in any part of North America. Only about one-tenth of the forms known to occur in Michigan are treated. However, the most outstanding edible and poisonous species are described and beautifully illustrated in its sixteen halftone plates. The work may be had in either paper or cloth. Further information may be secured by writing the author of the manual, indicated above.—FRED J. SEAVER.

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PODAXIS AEGYPTIACA

The interesting note on the distribution of *Urnula Geaster* in the current number of *Mycologia*, page 367, suggested by offering the following communication.

In April, Howard Dearness observed what he took to be two unlike species of stemmed puff-balls. They inhabited sandy desert tracts separated considerable distances from Alyce Springs in central Australia where the noon-day temperature reaches 120° F. He sent me a selected typical specimen of each both similarly releasing spores at the base of the peridium. One of them agreed with the description and herbarium material of *Podaxis pistillaris*. The other, a smaller, smoother and more slender plant was exactly like C. G. Lloyd's photo, No. 25, of *Podaxis aegyptiaca* Mont.

Under this name two descriptions are given in Saccardo's *Sylloge* in vol. 7: 58 and vol. 23: 589 differing a good deal in the size and somewhat in other terms, but nearly agreeing in the color of the glebal mass—"ferruginea rubra" and "aurantio-cinnamomei." The most striking macroscopic difference between the two specimens received was in the color of the glebal mass, that of the small one a peculiar bright rusty red.

*P. aegyptiaca*, if a valid species, is a widely distributed one, being reported from Asia, Africa, America and Australia and ranging from 30° N. to 30° S. of the equator. Although the color of the ripe gleba is apt to attract notice it is rarely reported judging from the records available to me. Respecting the validity of the species it should be noted that Miss E. E. Morse in a very careful study of *Podaxis* (*Mycologia* 25: 1-33. 12 plates), arrives at the conclusion that every specimen that she has examined is referable to

*Podaxis pistillaris*. She records 25 names that she has reduced to this one and strongly implies that nearly as many more, including *P. aegyptiaca*, should share the same fate. The two specimens under notice do seem however to be different species; and yet if every existing variation could be placed between them the gap might be filled.—JOHN DEARNESS.

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#### STUDIES ON THE AGARICACEAE OF HOKKAIDO

A comprehensive work under the above title has been published by S. Imai, in parts 1 and 2 of Volume 43 of the Journal of the Faculty of Agriculture, Hokkaido Imperial University, Sapporo, Japan. Three hundred and forty-eight species and forms are considered in detail, including important literature citations, synonymy, distribution, and an adequate description in English for each. Forty species, and three forms are described as new. In addition new combinations are made in the case of eighteen species and three forms, with one new name proposed. The author sets up six new subfamilies, fifteen tribes, fifteen subgenera, nine sections and four subsections. Of the 348 species and forms studied in Hokkaido, 233 are also reported from Europe and North America, 49 from Europe only, 23 from North America, while 43 are endemic or eastern Asiatic.

It is of interest to note that the author finds a considerable number of the forms studied intermediate between European and North American species. 196 of the species and one form are new to the flora of Japan.

181 species and four forms are considered edible, of which 74 species and two forms are suitable for market. A list of seventeen poisonous species is given. Approximately 50 of the species are illustrated. Adequate specific and generic keys as well as for large groups are provided.—JOHN A. STEVENSON.

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#### THE BULGARIA QUESTION

In adopting Fries' Systema Mycologicum as the starting point for the nomenclature of the fungi, as provided in the International Rules, confusion frequently results through the fact that Fries had

little knowledge of the microscopic characters of the fungi, and frequently species were grouped together in the same genus which had no close relationship, other than a superficial resemblance. A good illustration of this is the genus *Bulgaria*, which was established by Fries with *B. globosa*, an operculate species, as the first species mentioned and therefore regarded as the type. In the same genus he included *B. inquinans*, an inoperculate species. Since these cannot possibly be regarded as congeneric in present day treatments the writer in North American Cup-fungi retained the name *Bulgaria* with *B. globosa* as the type (Seaver, N. Am. Cup-fungi 194. 1928), while the name *Phaeobulgaria* was proposed (Mycologia 24: 253. 1932) for the inoperculate species typified by *B. inquinans* with its brown spores. This classification was adopted by Nannfeldt in his "Studien über die Morphologie und Systematik der Nicht-Lichenisierten Inoperculaten Discomyceten" (Nova Acta Reg. Soc. Sci. Upsal. IV. 8: 310. 1932).

Recently a Japanese student, Yosio Kobayasi, in a brief paper "On the gelatinous cup fungi, *Bulgaria*-group" (Jour. Japanese Bot. 13: 40. 1937) has reversed this treatment, and now proposes retaining *Bulgaria* for the inoperculate species, while the old untenable name, *Sarcosoma*, is resurrected for the operculate forms. While the writer, unfortunately, is unable to read the Japanese discussion leading up to these conclusions, it is very doubtful if this suggestion will be followed by American and European students of Discomycetes, since it is a violation of the International Rules of Nomenclature, and also reverses modern current usage.—  
FRED J. SEAVER.

# MYCOLOGIA

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## NEW OR NOTEWORTHY FUNGI FROM PANAMA AND COLOMBIA. IV

G. W. MARTIN

(WITH 40 FIGURES)

### *Cystobasidium sebaceum* Martin & Couch, sp. nov.

Resupinatum, effusum, pallidum, sebaceo-gelatinosum, siccum inconspicuum; substantio duplici: (1) hyphis conidiophoris anodosis; conidiis subovatis vel irregularis, truncatis,  $5-8 \times 4-5 \mu$ ; (2) hyphis basidiophoris nodoso-septatis; probasidiis subglobosis vel clavatis, parietibus leviter crassis; epibasidiis elongatis, rectis, dein valde inclinatis, demum transverse-septatis; basidiosporis ellipticis,  $6-8.5 \times 3-4 \mu$ .

Resupinate, thin, waxy-gelatinous, pallid and opalescent when fresh, drying to a thin, almost imperceptible film with white mycelioid margins, about  $5 \times 2$  cm. in extent, with interruptions; in section  $40-100 \mu$  thick; texture dense, with basal hyphae parallel with the substratum giving rise to hyphae apparently of two kinds: (1) conidial-bearing, without clamp connections, and (2) probasidial hyphae, with clamp connections; conidia thick-walled, subovate to irregular, with truncate base,  $5-8 \times 4-5 \mu$ , these forming a continuous layer or aggregated in pocket-like cavities; probasidia formed near surface, with slightly thickened wall, spherical, ovoid, pyriform or clavate,  $8.4-16 \times 5.8-10 \mu$ , each with basal clamp connection; epibasidia arising at apices of probasidia, usually curved, rarely cylindrical, thicker at distal end and 4-celled by transverse septa,  $21-28 \times 4-7 \mu$ , not including the slender stalks, variable in length or occasionally lacking, by which they are attached to the hypobasidia, frequently bent abruptly at the junction of the stalk and the main body of the epibasidium, upon which the basidiospores are produced unilaterally, each upon a sterigma  $4-6$

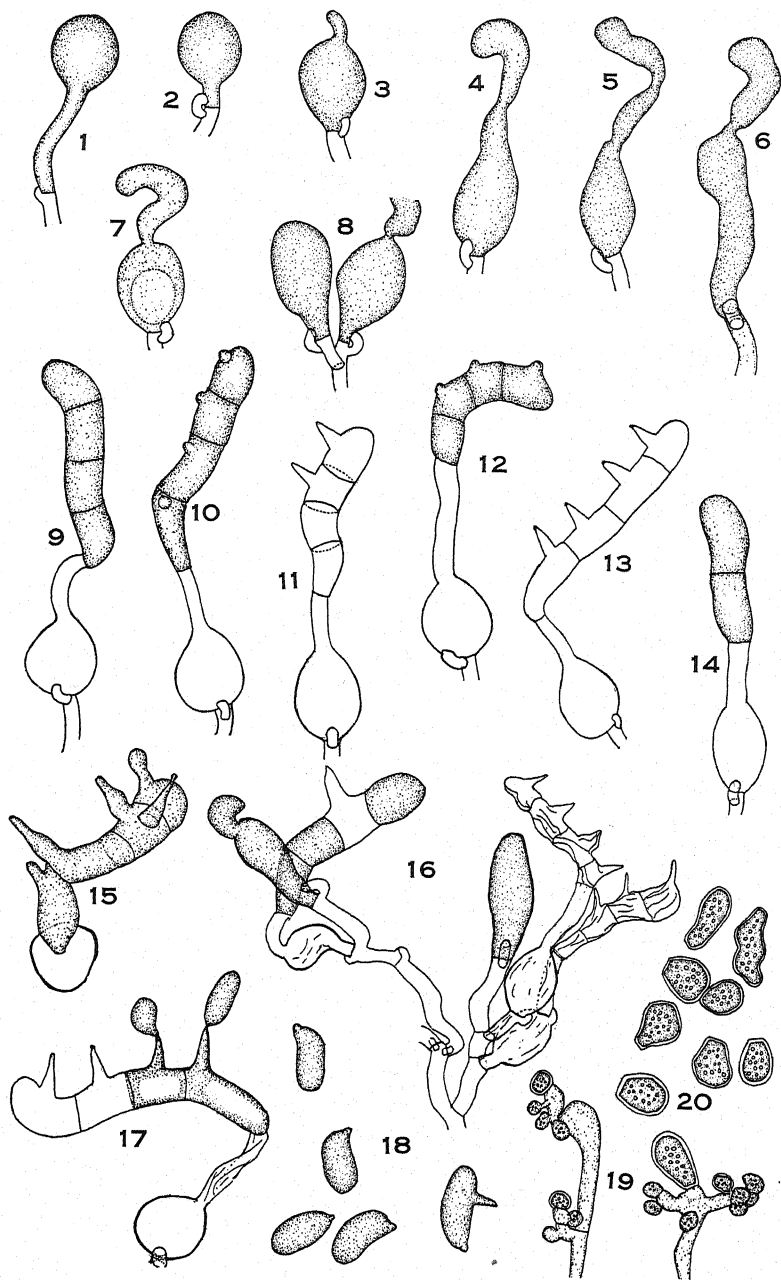


(-10) $\mu$  in length; basidiospores hyaline, elliptic, depressed ventrally, with distinct hilum,  $6-8.5 \times 3-4 \mu$ .

Colombia: Dept. Magdalena, Hacienda Cincinnati, alt. 1250-1500 m., Aug. 24, 1935. On decaying wood overgrowing remnants of an old *Sebacina*. G. W. M. 3686, type, in herb. State Univ. Iowa and Univ. No. Car.

Lagerheim (Bih. Sv. Vet.-Akad. Handl. 24<sup>4</sup>: 15. 1898) established the subgenus *Cystobasidium* to accommodate his new species *Jola lasioboli*, a fungus occurring as a parasite on *Lasiobolus equinus* (Müll.) Karst. in Norway. The essential differences between Lagerheim's species and other species of *Jola* reported up to that time, aside from the fact that the latter are all tropical parasites upon mosses, are the non-gelatinous character of *Cystobasidium* and the nature of the basidia, which in *Jola* arise from thin-walled probasidia and are approximately straight or evenly curved, while in *Cystobasidium* the probasidia are distinctly thick-walled and the epibasidia tend to bend at a right angle at or near the junction of the slender connecting stalk and the fertile, 4-celled terminal portion. Gäumann (Vergl. Morph. Pilze 414. 1926) recognizes *Cystobasidium* as a genus, grouping it with *Jola* and *Saccoblastia* (i.e. *Helicogloea*) in the family Cystobasidiaceae. Dodge, in his revision of Gäumann's work (Comp. Morph. Fungi 546. 1928), maintains the genus, but includes it, with the other two genera named, in the Septobasidiaceae. Couch (Genus Septobasidium 65. 1938) believes that the symbiotic relation of *Septobasidium* with scale insects justifies the separation of that genus from the Auriculariales. The close relationship of *Cystobasidium* with *Jola* and *Helicogloea* may be granted, but the validity of their segregation as a family may be questioned.

When fresh, the collection here discussed was in the form of a thin, grayish white, opalescent, gelatinous sheath, growing on decaying wood and macroscopically indistinguishable from several of the thin, resupinate, waxy-gelatinous forms at present included in *Sebacina*. Under the microscope, however, it proved to possess transversely septate epibasidia arising from thick-walled, vesicular probasidia and connected with the latter by a slender filament as described and illustrated (FIGS. 1-17). The basidiospores apparently germinate by repetition (FIG. 18). The conidia (FIGS. 19-



FIGS. 1-20. *Cystobasidium sebaceum*.

20) have every appearance of being borne on the same fructification, although this cannot be regarded as completely certain. The description of *Jola orthosacca* Rick (Egatea 18: 210. 1933) suggests a similar fungus, but a collection of the latter kindly sent to me by Father Rick proves to be wholly distinct.

Associated with the transversely septate basidia and the conidia were a few typical cruciate-septate basidia of the tremellaceous type and a mass of disorganized gelatinous material suggesting that the *Cystobasidium* was growing upon an old *Sebacina*, although there is no evidence of parasitism.

I am indebted to Dr. John N. Couch for help in interpreting this difficult form; the drawings illustrating it are his.

#### PATOUILLARDINA CINEREA Bres.

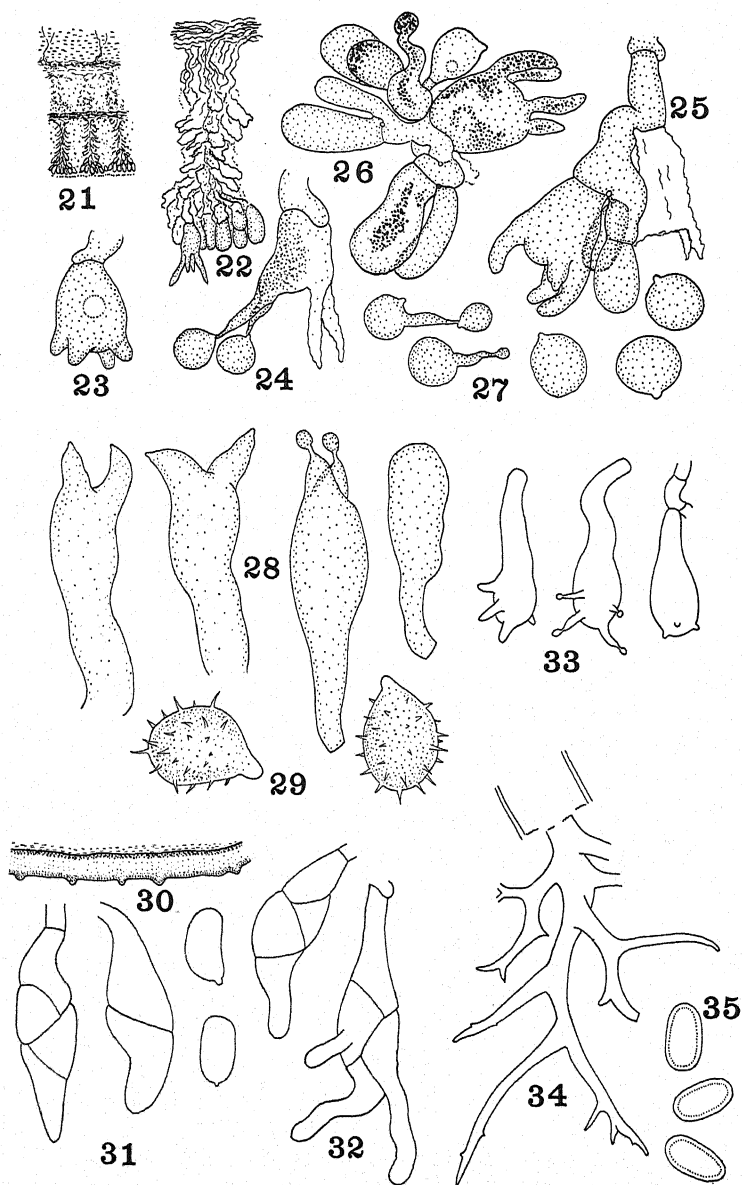
Under the heading "Atractobasidium," Rogers (Mycologia 28: 398. 1936) has discussed the synonymy of this species. A collection from the island of Taboga (G. W. M. 4480) affords opportunity for further comment.

The original publication of Bresadola's name was in a paper by Rick (Broteria 5: 7. 1906). Neither genus nor species is designated as new and no formal descriptions are furnished, but merely informal comment, the essential part of which is as follows: "Dieser . . . Pilz unterscheidet sich makroskopisch nicht von *Corticium* oder resupinatem *Stereum*. . . . Allein die horizontal getheilten Basidien lassen über seine Zugehörigkeit zu den Auriculares kein Zweifel. Es ist ganz eine *Platyglea*, die nicht gelatinös ist." This would scarcely constitute valid publication even if the particulars given were correct. Whether the fact that they are very nearly completely incorrect has any bearing on the validity of the publication, the rules being what they are, may be doubted. In any event, fourteen years later, Bresadola (Ann. Myc. 18: 52. 1920) wrote formal descriptions of both genus and species, citing the earlier account as the place of original publication, and repeating the errors. Trotter (Sacc. Syll. Fung. 23: 568. 1925) recognizes the 1920 publication as the valid one, as does Killermann (Engler & Prantl. II. 6: 108. 1928). In 1917, however, Arnaud (Compt. Rend. Acad. Sci. Paris 164: 890) had proposed *Patouillardina* as a genus of the Meliolaceae, based on *Meliola clavispora*

Pat. Arnaud's genus is listed, but the reference incorrectly cited, in the Sylloge 24: 505. On the basis of Trotter's treatment, therefore, Bresadola's name is a homonym. Later, Rick based *Platyglea Grandinia* (Egatea 18: 211. 1933) and *Protograndinia cinerea* (l. c. 213) on specimens apparently representing the same species but differing in external appearance and particularly in the configuration of the hymenium, the basidia being in all these species described as transversely septate in auriculariaceous fashion.

The genus *Atractobasidium* (Bull. Torrey Club 62: 339. 1935) was established for a fungus from Mexico with spindle-shaped, obliquely septate basidia in which the secondary septa are consistently at right angles to the primary septum, obviously related to the Tremellaceae rather than the Auriculariaceae. It was only by examining specimens that Baker discovered that the basidia of *Platyglea Grandinia* were the same, and Rogers (l. c.) established the identity of the other species.

In view of this confusion it is of interest to be able to report on a specimen seen in good condition in the field. The fungus was growing on dead branches of a scrubby tree along the trail to the summit of Taboga just below the point where the scrub gives way to grass. It was definitely gelatinous and the hymenium was covered with small teeth. These, with its general suggestion of a Heterobasidiomycete, led me to label it "*Heterochaete*," under which name it was filed for later study. Under the microscope, the characteristic basidia (FIG. 31) permitted immediate recognition of the genus. Whether there is more than one species involved is still uncertain. When soaked and sectioned, the Taboga specimen is shown to have rather blunt and not at all specialized spines (FIG. 30). A specimen of *Platyglea Grandinia*, collected by Rick in Brazil and now in the collection of the Missouri Botanical Garden, has similar spines, although in scantier number. The hymenium of the type of *Atractobasidium* is practically smooth. The basidia and spores of all three are essentially alike, the differences in size being well within the limits of variation as found in species of this group. It seems permissible, therefore, to consider that these forms all represent a single species, widely distributed in the American tropics, rather variable in external characters, but reasonably uniform in the more fundamental microscopic features.



FIGS. 21-27, *Ceratobasidium plumbeum*; 28-29, *Lachnocladium giganteum*; 30-32, *Patouillardina cinerea*; 33-35, *Nidularia reticulata*.

It must be admitted that it will require a generous extension of the provisions of Art. 43 of the rules to recognize the 1906 publication of *Patouillardina* as valid but it is to be hoped that this may be conceded. It is eminently appropriate that Patouillard's name should be associated with a striking genus of the group which his studies did so much to illuminate. On the other hand, if *Patouillardina* Bres. is to be rejected in favor of Arnaud's use of the name, then the genus must be known by Rick's name *Protograndinia*, thus perpetuating the discredited theories of Brefeld, whose meretricious treatment of the group has been largely responsible for the tardy recognition of Patouillard's work.

***Ceratobasidium plumbeum* sp. nov.**

Fructificatione resupinata, viva plumbea, sicca atra; probasidiis clavatis, 12-15  $\times$  9-11  $\mu$ ; epibasidiis crassis, cornutis vel subfusiformis; basidiosporis globosis vel late ellipsoidis, 6-8  $\mu$  diam., per repetitionem germinantibus.

Broadly but interruptedly effused, indeterminate, deep grayish-olive when soaked, drying dull olivaceous black or fuscous black, in section about 75  $\mu$  thick, or, when stratified by the superposition of a second layer over an older one, 150  $\mu$  thick; structure consisting of a thin layer of basal hyphae parallel with the substratum, 10-15  $\mu$  thick, an intermediate layer composed of erect, pillar-like strands bearing collapsed basidia and separated by a gelatinous matrix and supporting a continuous hymenial layer; probasidia broadly cylindrical or clavate, borne in terminal clusters, with conspicuous, proliferating clamp connections, finally 12-15  $\times$  9-11  $\mu$ , developing four, rarely three or two, thick, conical or sub-fusiform epibasidia, usually tipped with a sterigma and basidiospore, but some remaining sterile; basidiospores with a conspicuous apiculus, globose, 6-8  $\mu$  in diameter, or broadly ovate or depressed, up to 9  $\times$  8  $\mu$ , germinating by repetition.

Panama: Canal Zone, in low forest 3 k. east of Arraiján, Sept. 1, 1937. G. W. M. 4597, type. In herb. State Univ. Ia. and Missouri Bot. Gard. Growing on under side of decaying log.

The genus *Ceratobasidium* was established by Rogers (Univ. Iowa Stud. Nat. Hist. 17: 4. 1935) to include certain resupinate Basidiomycetes having unseptate basidia bearing stout, cornute or spindle-shaped epibasidia and with basidiospores germinating by repetition. As Rogers points out, the genus is intermediate between the Heterobasidiomycetes and the Homobasidiomycetes, but

although its affinities are rather with the former group than with the latter, under the system of classification commonly used at present, it must be included in the Thelephoraceae, itself a tentative and badly limited family that must eventually be discarded.

The present species is strikingly characterized in section by the hyphal pillars, perpendicular to the substratum, bearing clusters of basidia at the apex (FIGS. 21, 22), proliferating from the conspicuous clamp connections (FIGS. 25, 26) and surrounded by the collapsed basidia throughout their length, much as is the case in certain species of *Bourdopia*. Although four epibasidia are commonly formed, there is a suggestion that all do not function, while later spores, apparently mature (FIG. 24), are apt to be small. This, as well as the reduction in size due to germination by repetition, may account for the great variation in spore size, a common phenomenon in the Heterobasidiomycetes and much less common, although not rare, in the Homobasidiomycetes.

Many of the hyphae and the older, emptied basidia, and occasionally some probasidia are more or less densely charged with a blackish-brown granular deposit (FIG. 26), causing them to look yellowish-brown under the lens and doubtless largely responsible for the dark appearance of the fructification as a whole.

#### EPITHELE DUSSII Pat.

According to Burt (Ann. Missouri Bot. Gard. 6: 265. 1919) known only from Gaudeloupe and Venezuela. An ample collection on dead leaves of a royal palm on the grounds of the Missouri Botanical Garden Tropical Station at Balboa (G. W. M. 4215), while sterile, is certainly an *Epithele* and is almost certainly the present species. The fructification, thickly studded with the striking, sterile, tooth-like fascicles, is broadly effused, as was the Venezuelan specimen studied by Burt.

#### CRATERELLUS CORNUCOPIOIDES Pers. ex Fries

The range of this common temperate species is given by Burt (Ann. Missouri Bot. Gard. 1: 334. 1914) as "Canada to South Carolina and Missouri." Three collections from western Panama, on the slopes of El Volcan in Chiriquí, two at about 1700 m. and one at 1900 m., notably extend the known range and emphasize the temperate element in the fungous population of the tropical mountains.

## LACHNOCLADIUM GIGANTEUM Pat.

Originally reported from French Guiana (Jour. de Bot. 3: 34. 1889), this species is not included by Burt among the North American forms. The single collection I refer to it was collected by A. M. Bouché, Jr., in the Valle Chiquita, south of El Valle de Antón, Prov. Coclé, Panama, in July, 1935 (G. W. M. 2989, FIG. 36). While I have not been able to compare it with authentic material, the large size, the stout stipe from which the dichotomous branches arise, the blackish-brown color when soaked and the large brown spiny spores agree satisfactorily with Patouillard's description and the accompanying illustrations. Patouillard includes the species in his section *Dendrocladium*, characterized in part by a unilateral hymenium. In the specimen under consideration, the hymenium is unilateral below, but amphigenous nearer the tips.

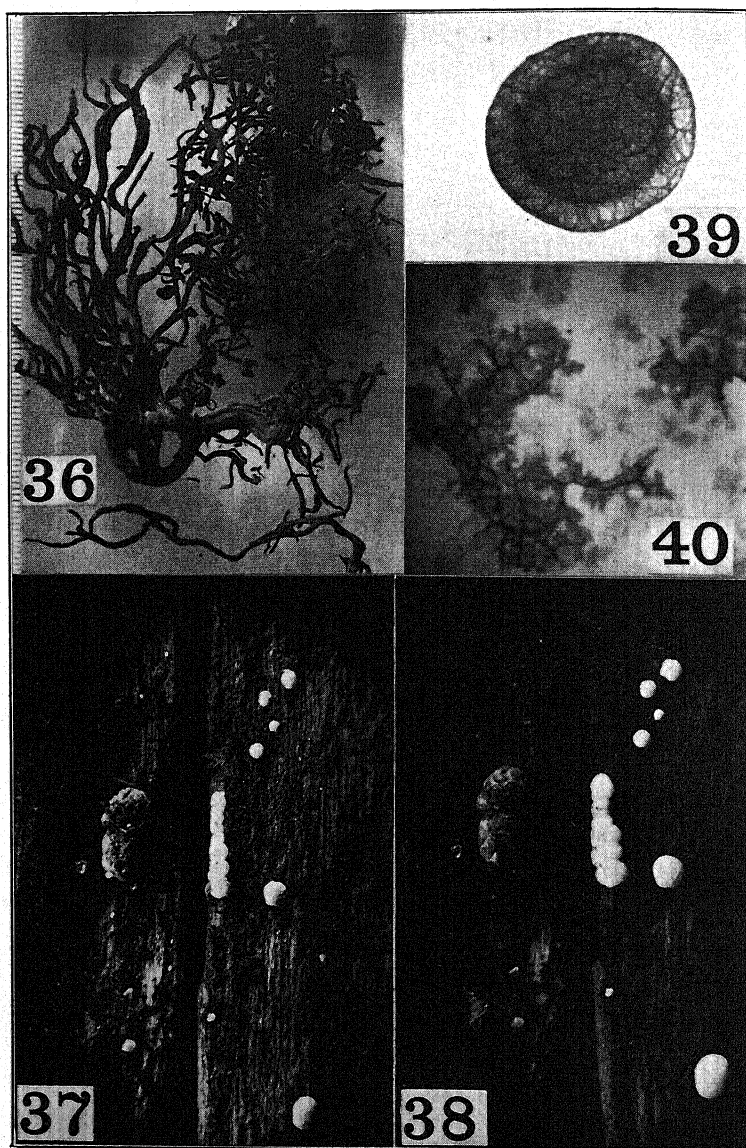
The basidia are very striking. At first cylindric-ovate on a sharply constricted stalk, they become clavate and develop two thick apical branches (FIG. 28), much like the epibasidia of the Dacrymycetaceae, but shorter, at the tips of which are small, but distinct sterigmata, each of which bears a spore. The spores are yellowish-brown, the body, including the thick, blunt apiculus, which is often attached at an abrupt angle,  $13-16 \times 8-10 \mu$ . The long spines are sparsely and somewhat irregularly disposed (FIG. 29). Patouillard's spore measurements are slightly but not significantly smaller,  $12-15 \times 8-9 \mu$ .

Burt (Ann. Missouri Bot. Gard. 6: 267. 1919) believes that species of *Lachnocladium* with dark-colored, rough or muricate spores are better referred to *Thelephora*. Useful as spore characters are, the nature of the basidium is even more fundamental, and the present species would be as foreign to the typical *Thelephoras* as it is to the *Lachnocladiums* with smooth hyaline spores. For the present it seems unnecessary to remove it from *Lachnocladium*.

## NIDULARIA RETICULATA Petch.

This species has heretofore been known from a single collection from Ceylon. It was originally reported by Berkeley and Broome (Jour. Linn. Soc. 14: 81. 1873) as *N. Duriaeana* Tul. (Ann. Sci.





FIGS. 36, *Lachnocladium giganteum*; 37-40, *Nidularia reticulata*.

Nat. III. 1: 99. 1844). Petch submitted a portion of the type collection to Lloyd (Myc. Writ. 2. Letter 19: 1. 1908), who pronounced it wholly unlike Tulasne's species, whereupon Petch (Ann. Royal Bot. Gard. Peradeniya 7: 60. 1919) described it as new.

The collection which I refer to this species was growing on the fallen sheath of a banana at Balboa, C. Z., in August, 1937 (G. W. M. 3985). The basidiocarps, while small, are rather conspicuous when young, because of their pure white color. Later, by the gelatinization of the peridium, they take the pale brownish color of the peridioles, and are then inconspicuous. They are subglobose, finally 2 mm. or slightly more in diameter, or up to 4 mm. by anastomosis. The peridium dries as a very thin, horny, transparent sheath which becomes gelatinous and pallid when soaked (FIGS. 37, 38). The peridioles are lenticular, unattached, 0.45 to 0.55 mm. in diameter and 0.2 mm. thick and bright yellowish-brown when soaked. Under low magnifications they have a striking appearance, well brought out in the accompanying photograph (FIG. 39). The surface appears to be strongly reticulate, with a broad translucent margin surrounding a denser central portion. A section at right angles to the broader dimension shows that there is a thin membranous outer wall from which arise stout, brown, antler-like hyphae, about  $10\mu$  in diameter at the bases, which branch repeatedly, but with little or no anastomosis, forming a floccose intermediate layer (FIGS. 34, 40). The inner layer, about three or four cells in thickness, appears to be wholly free from the intermediate layer, but gives rise directly to the pseudoparenchymous subhymenium, of approximately equal thickness. The hymenium is clearly defined, composed of a single compact palisade layer of basidia. The basidia (FIG. 33) bear four spores in somewhat irregular fashion. The spores (FIG. 35) are hyaline, cylindrical, thick walled, without apiculus,  $8.5-9.5 \times 4.5-5.5\mu$ .

There are minor differences between the Panama specimens and those from Ceylon. Berkeley and Broome give the spore size as  $.0003 \times .0002$  inches (*i.e.*, about  $7.5 \times 5\mu$ ). Petch states that the peridioles are up to 0.75 mm. in diameter, noting, however, that the Peradeniya specimens appear to be immature. Lloyd (l. c.) states that an antler-like middle layer is known elsewhere

only in *Nidula emodensis* (Berk.) Lloyd, which is otherwise quite distinct. Tulasne (l. c. *pl.* 7, *f.* 12) shows similar structures in *Nidularia australis* Tul., from Chile, which, both in Tulasne's drawing (l. c. *pl.* 7, *f.* 2, 3) and in Lloyd's photograph (Myc. Writ. 2. Nidulariaceae 9, *f.* 8) shows strong resemblance to *Nidula*.

Since in most respects the Panama specimens agree very closely with *N. reticulata* as described by Petch, and since the differences are no greater than might be expected from two widely separated collections, it seems advisable to regard both as representing a single species.

#### EXPLANATION OF FIGURES

Figs. 1-20. *Cystobasidium sebaceum*. 1-8, various forms of probasidia with early stages in development of epibasidia; note clamp connections at base; 9-13, later stages in development of epibasidia; 14, two-celled epibasidium; 15, epibasidium with two sterigmata arising from penultimate segment; 16, cluster of basidia in various stages; 17, mature basidium with spores partly discharged; 18, five basidiospores, one germinating by repetition; 19, development of thick-walled conidia; 20, detached conidia, showing variation. Drawn by J. N. Couch,  $\times 1000$ .

Figs. 21-27. *Ceratobasidium plumbeum*. 21, diagrammatic longitudinal section through fructification, showing a second layer overgrowing an old layer,  $\times 110$ ; 22, a single pillar showing basal layer, collapsed basidia and surface hymenium,  $\times 460$ ; 23, young basidium with epibasidia developing; 24, older basidium with two collapsed epibasidia from which basidiospores have been discharged, protoplasm apparently still passing into remaining two basidiospores; 25-26, two clusters of basidia showing proliferation from clamp connections; 27, five basidiospores, two germinating by repetition. Figs. 23-27,  $\times 1000$ .

Figs. 28-29. *Lachnocladium giganteum*. 28, young basidium, at right, and three older stages; 29, two spores. Both  $\times 1000$ .

Figs. 30-32. *Patouillardina cinerea*. 30, diagrammatic section through fructification of No. 4480 from Taboga,  $\times 8$ ; 31, two basidia and two spores of same,  $\times 1000$ ; 32, two basidia from a collection of *Platyglea Grandinia* Rick, collected by Rick in Brazil,  $\times 1000$ .

Figs. 33-35. *Nidularia reticulata*. 33, three basidia; 34, base and tip of antler-like hypha from peridiole wall; 35, three basidiospores. All  $\times 1000$ .

Fig. 36. *Lachnocladium giganteum*, no. 2989. Slightly reduced, the scale at left is in millimeters.

Figs. 37-40. *Nidularia reticulata*, no. 3985. 37, immature fructifications, at right, and mature ones, at left, dry,  $\times 4\frac{1}{2}$ ; 38, same, soaked, at same magnification; 39, peridiole, mounted whole  $\times 50$ ; 40, antler-shaped hyphae from crushed mount of peridiole,  $\times 50$ .

# THE SQUIRREL AS A NEW HOST TO A RINGWORM FUNGUS

EDWARD D. DeLAMATER

(WITH 3 FIGURES)

## A. INTRODUCTION

During the year 1936 and 1937 a noticeable number of the common gray squirrels living on and near the Johns Hopkins University Campus at Homewood, Baltimore, were observed to have a serious skin infection. During the spring of 1936 sick animals were obtained, but no causative organisms were retrieved in culture, due to overgrowth of saprophytes. Fungi were, however, observed in the skin on direct examination.

During the following winter, 1936-1937, the disease was observed to be still rampant. On March 19, 1937, a sick animal was again obtained for observation and mycological study begun. It was found that the squirrel represents a new host to the ringworm fungi.

## B. THE DISEASE

1. *Macroscopic appearance of lesions in the squirrel:* The lesions observed in squirrels were typical of tinea. They were widespread and definitely circinate. The borders of adjacent lesions ran into one another and produced large irregular confluent patches. The lesions were not localized, as in similar diseases of the horse, for example, but covered practically every part of the body. The dorsal, ventral, and lateral aspects of the body were widely infected, the fore and hind limbs, the tail, the throat, and face. Nearly all the infected squirrels observed had lesions similarly extended (FIG. 1).

The lesions themselves had the following aspects: They were extensively epilated, leaving much of the body surface devoid of fur. The epilated lesion surfaces were covered by a dense coat of small scales. There were no heavy exudative crusts. Under

the scales the infected skin was dotted by multiple pin-point vesicles. The lesion borders, studded with solitary remaining hairs, were slightly raised and slightly inflammatory (FIG. 1).

2. *Microscopic*: Upon direct examination of scales and hair, observed by placing scrapings on a slide in 10–15 per cent NaOH, numerous ramifying filaments of the invading fungus were observed. In the scales these filaments tended to fragment into chains of arthrospores, giving the appearance of a closely packed chain of cuboidal beads; the adjoining cells were in close abutment.

In infected hairs the fungus was seen both within and around the hair shafts. When in the hair the filaments were again fragmented into chains of cuboidal arthrospores, which followed tortuous channels through the hair shaft. When outside, the elements were in the form of a closely packed sheath of small (microide) spores lying just below the hair cuticle. Usually the arthrospores of the spore sheath were so closely packed as to have lost their filamentous relationship. Here and there, however, their filamentous origin was still apparent.

*Autopsy*: Material was taken of a diseased part; sections were made and stained by the methods of Heidenhain (hematoxylin-eosin) and of Gram. The observations just recorded for direct examination were verified. Figure 2B is a photo of an infected hair from the autopsy sections. The chains of fungous spores are seen to lie in the hair shaft.

#### C. THE CAUSATIVE FUNGUS—ISOLATION

The causative fungus as it appears in the lesions has just been described.

In obtaining the fungus in culture two methods were used. In the first, the lesions were carefully swabbed with 80 per cent alcohol and then scraped with a sterile scalpel. The scrapings were placed in the surface of honey agar slants (Sabouraud) and incubated at room temperature. When a suspicious looking growth was observed amongst the concurrently growing saprophytes, it was carefully isolated and inoculated into new tubes, until pure cultures were obtained.

In the second method, lesion scrapings were rubbed directly into the scarified surface of the skin of three guinea pigs. This



FIG. 1. Gray squirrel infected with *T. mentagrophytes* (*gypseum*).

method served also as a test for direct disease transmission and virulence and will be considered presently. The infected animals were carefully observed every day. When it appeared certain macroscopically that a disease had been successfully passed, direct microscopical examination was made as above and cultures were taken. By this method the same fungus was obtained both from the squirrel directly and from the infected guinea pigs. Tests were then made on fresh guinea pigs with the fungus obtained in pure culture from both the original squirrel and the experimental animals. Pure cultures were again retrieved from this series. The pathogenicity of the fungus isolated was proven and Koch's postulates fulfilled.

#### THE FUNGUS IN CULTURE

2. *Macroscopic*: When cultured on Sabouraud's honey or maltose agars the colonies are characteristic and similar and are typical of *Trichophyton mentagrophytes* (*gypseum*) Robin, Sabouraud. This cultural character along with the previously noted ectothrix microide character of the fungus in the hair, aid in the taxonomic placement of the fungus. The surface of the colony is flat and very powdery. At the periphery the edges are frayed radially. The color is white or cream to buff. Figure 2A is a photograph, natural size, of such a colony three weeks old. The back side of the colony characteristically shows a wine-red color.

On corn meal or potato agar the aerial growth is less profuse and the colony color is more nearly white. The red pigment appears in potato agar cultures but not in corn meal agar cultures.

3. *Microscopic morphology*: The microscopic morphology of *T. mentagrophytes* (*gypseum*) is just as characteristic as the colony in Sabouraud's agar and in general offers few obstacles for identification, a confusing synonymy of specific names notwithstanding.

*Honey and maltose agar cultures*: These media give nearly identical results both culturally and morphologically. All of the structures represented by the drawings in figure 3, with the exception of 3D are found on these media. Figure 3A is a typical branching cluster of aerial hyphae. Figure 3B represents an intermediate stage between this and the characteristic en grappes cluster of aleuriospores (microconidia) represented in figure 3C (1, 2, 3).

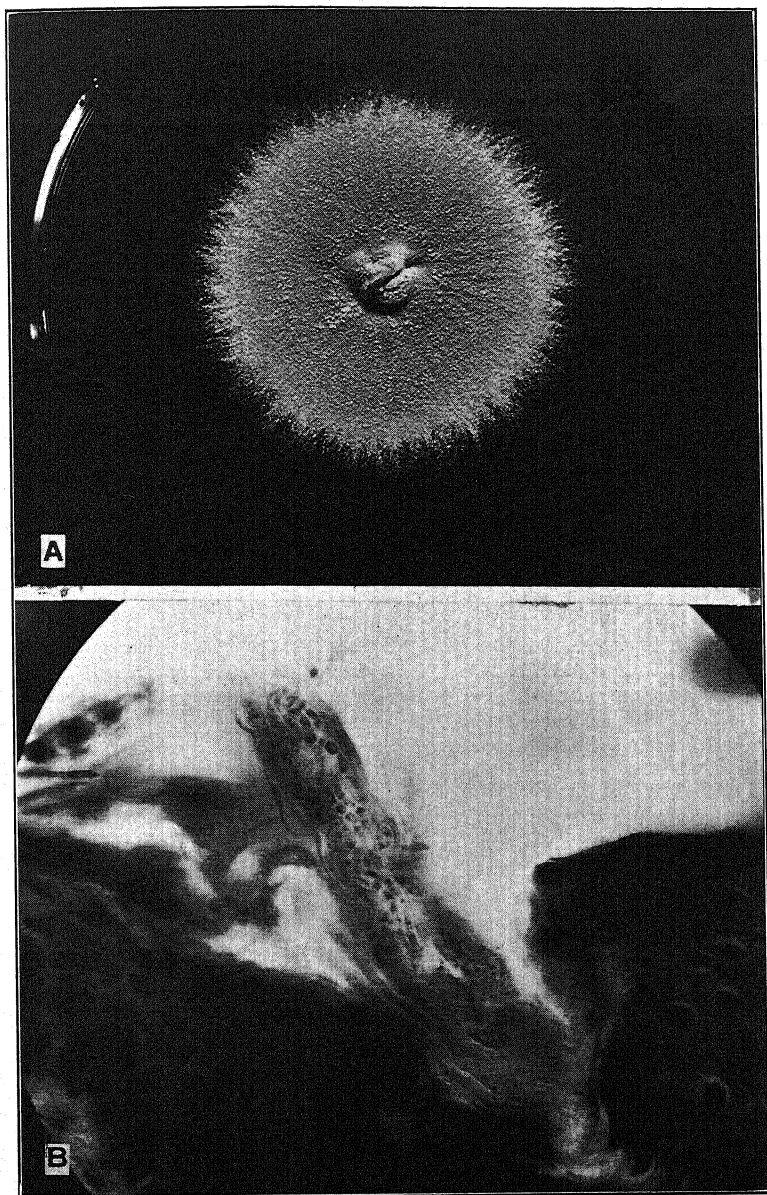


FIG. 2A. 20 day old maltose agar culture *T. mentagrophytes* (*gypseum*).  
 FIG. 2B. Biopsy section of squirrel lesion showing infected hair.



The swollen cells bearing aleuriospores shown in 3D was not observed on these media. Figure 3E represents various configurations of the thyrses or aecidium type of aleuriospore fruiting so typical of nearly all the dermatophytes. Figure 3F represents the racquette mycelium typical of these fungi, but also found in the Gymnoascaceae and in *Coccidioides immitis*, etc. Figures 3G and 3J are two types of chlamydospores, the terminal and intercalary, respectively. Figures 3H, 1 and 2, are spirals showing wide dissimilarity in configuration. Figure 3I is a so-called nodular organ, so suggestive of an abortive sexual phase. These structures simulate closely the early sexual development as seen in the lower Ascomycetes (Plectascales). Figure 3K shows typically irregular subsurface hyphae. These are deeply imbedded in the substrate, are thin-walled and suggest an absorptive function. Figure 3L shows the typical fuseaux (macroconidia) of the *T. gypsum* group. The occurrence or relative profuseness of these structures may vary appreciably between different strains of the same fungus. In corn meal agar, in contrast to the wealth of morphological structures just described for honey and maltose agars, several structures are not formed. There are no swollen, aleuriospore bearing hyphae, fuseaux, nodular organs, and relatively few spirals. In potato agar only nodular organs are missing, although spirals are less frequent than on other media. Swollen, bulbous, aleuriospore bearing cells (FIG. 3D) are present, but not abundant. This is the only media on which they were observed.

#### D. VIRULENCE OF THE FUNGUS

DeLamater and Benham<sup>1</sup> have reported numerous experiments on the experimental disease produced by this and related fungi. These need not be detailed here, but certain facts deserve brief consideration.

Direct transmission of the disease from the infected squirrel to guinea pigs by using infected scales has been noted, and also that the disease was reproduced by the direct application of material

<sup>1</sup> DeLamater, E. D. & Benham, R. W. Experimental studies with Dermatophytes. 1. Primary disease course in laboratory animals. 2. Immunity and hypersensitivity produced in laboratory animals. Jour. Inv. Derm. 1: 451-488. 1938.

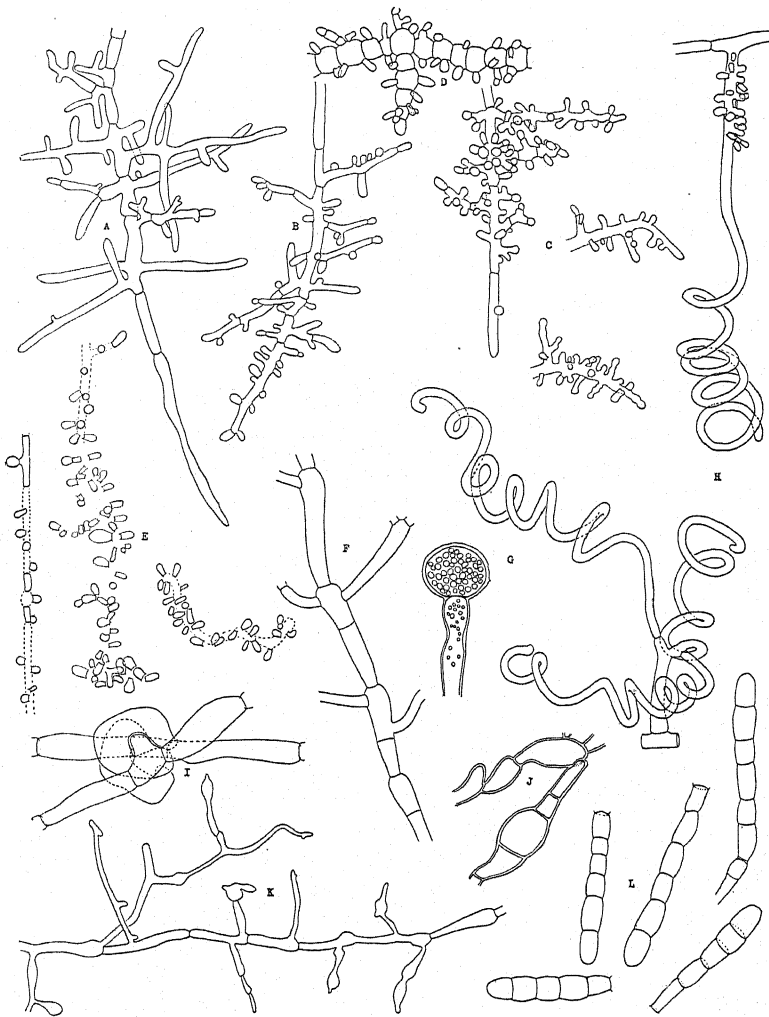


FIG. 3A-L. Microscopic structures found in *T. mentagrophytes* (*gypseum*) on various media.

from pure cultures. In addition, it should be stated that normal animals not only in direct contact with infected animals, but also several in separate cages at a distance of two or more feet from the infective source became ill. This gives a rough idea of the virulence of the fungus, even though the spores were wind blown (or otherwise transmitted) and no previous scarification was done

for the purpose of aiding the "take." The character of the disease produced was further evidence of the virulence of this fungus.

Cats and rabbits were also shown to be susceptible to this strain of *T. gypsum* and in two cases accidental infection of human subjects occurred.

#### SUMMARY <sup>2</sup>

The squirrel is described for the first time as host to an already well known ringworm fungus, *T. mentagrophytes* (*gypsum*) (Robin-Sabouraud).

#### EXPLANATION OF FIGURES

Fig. 1. Photograph of infected squirrel showing extent and character of lesions—about  $\frac{1}{2}$  natural size. Fig. 2*A*. Photograph of a 20 day maltose agar (Sabouraud) culture, natural size, showing characteristic cultural characters; 2*B*. Biopsy section of squirrel lesion showing infected hair (endothrix); about 1200  $\times$ . Fig. 3*A*. Aerial hyphal clump, corn meal agar, one month; about 300  $\times$ ; *B*. Transitional stage between Fig. 1 and 3, corn meal agar; about 300  $\times$ ; *C*1, 2, 3. En grappes cluster of aleuriospores (microconidia), corn meal agar, one month; about 300  $\times$ ; *D*. Swollen cells bearing aleuriospores, 3 week potato agar culture; about 300  $\times$ ; *E*. Thyrses—acladium type aleuriospores (microconidia), one month corn meal culture; about 300  $\times$ ; *F*. Racquette mycelium (aerial or surface), corn meal agar, one month; about 300  $\times$ ; *G*. Terminal chlamydospore containing oil droplets. Honey agar culture, one month; about 600  $\times$ ; *H*1. Spiral with basal cluster of microconidia, one month corn meal agar culture; about 300  $\times$ ; *H*2. Multiple spirals; *I*. Nodular organ, 4 month honey agar culture, suggesting abortive sexual phase; about 600  $\times$ ; *J*. Intercalary chlamydospores (subaerial), granules, one month corn meal culture; about 300  $\times$ ; *K*. Subaerial hyphae, 4 month honey agar culture; about 600  $\times$ ; *L*. Fuseaux (macroconidia), one month honey agar; about 300  $\times$ .

<sup>2</sup> A complete reference list of the material available on animal infections due to the ringworm fungi will appear soon with a review of the subject, in the Botanical Review.

## A NEW SPECIES OF LAGENIDIUM PARASITIC ON ROTIFER EGGS<sup>1, 2</sup>

F. K. SPARROW, JR.

(WITH 15 FIGURES)

While the majority of the Lagenidiales are parasitic on species of fresh water algae, a few have been observed on microscopic animals, as for example, *Myzocyttium vermicolum* Zopf, on eel worms, and *M. zoophthorum* Sparrow, on eggs and adults of the Rotiferae.

In May, 1937, a virulent parasite belonging to this order developed in rotifer eggs occurring in gross cultures of aquatic debris collected in the Huron River near Ann Arbor, Michigan.

The infecting agent is a relatively large, laterally biciliate zoospore of the "secondary," "grape-seed-like" type (FIG. 15), practically identical with that formed by species of *Pythium*. Upon coming to rest on the outer wall of the egg the spore encysts and very soon produces a short, blunt germ tube which pierces the wall of the intended host (FIG. 1). The broad tip of this tube then increases in width and, as the contents of the extramatrical cyst are gradually conveyed into it, assumes a spherical shape (FIGS. 2, 3). The transference of this material into the egg takes about fifteen minutes. Inside, the walled sphere of fungous protoplasm rests in contact with the living, maturing rotifer. Within two hours the parasite has doubled in size and definite signs of body disorganization of the animal and cessation of rhythmic pulsation are apparent. As the thallus enlarges, the contents of the egg are absorbed (FIGS. 4-7) and eventually only a few brownish granules remain. During development of the thallus, particularly in cases where only a single infection has occurred and hence where ample space is available, broad lobes are formed on the somewhat ellipsoidal or irregular body. The contents of the fungus which during early stages of

<sup>1</sup> Paper from the Botany Department, University of Michigan No. 686.

<sup>2</sup> Acknowledgment is made to the Faculty Research Fund for financial aid given in connection with the preparation of this paper.

development were somewhat transparent and watery in appearance become as growth continues dark, dense and full of irregular, refractive granules.

At maturity, the thallus consists of a single celled, sac-like body with one or more broad lobes (FIGS. 8, 9). When several thalli occupy a single egg, a not uncommon condition, little or no tendency towards lobulation is noted (FIG. 8). If conditions are favorable, the whole structure is soon transformed into a single sporangium. During maturation a broad discharge papilla is formed which pierces the wall of the egg. At its apex, which just protrudes from the egg, a crescent-shaped layer of refractive material appears, beneath which is a clear area. In the later stages of development isolated vacuoles appear and disappear and the protoplasm eventually becomes finely granular and shot throughout with minute refractive granules (FIG. 9). A few minutes before spore discharge furrows are visible which delimit what are probably the spore initials. This is quickly followed by the sudden appearance of a large central vacuole which extends throughout the whole structure, the protoplasmic contents at this stage appearing in optical section as crenulations along the inner walls (FIGS. 10-11). After a few seconds the vacuole suddenly disappears and the protoplasm becomes homogeneous save for regularly placed, shadowy areas about the size of the spore initials. At this moment, the hyaline tip of the discharge tube enlarges, loses its double contour and refractivity, and evacuation of the contents is initiated (FIG. 12). The protoplasm flows out smoothly and steadily, forming outside a constantly enlarging spherical mass. Before all the protoplasm has been discharged, the spore initials are visible in the material outside and these almost instantly become separated into somewhat angular bodies (FIG. 13). Around the periphery short, hyaline cilia may be seen actively undulating (FIG. 14). The whole mass of discharged spores, consisting at times of seventy-five to one hundred or more individuals, assumes a rocking motion to which is eventually added a slight rotation. No vesicle has been observed. After ten minutes, or less, the zoöspores, which have now become somewhat separated but are still in a spherical or hemispherical cluster at the orifice of the sporangium, gradually increase their speed of movement and each

quickly assumes a rapid lateral vibratory motion. There then ensues a period of only a few seconds duration of extremely rapid vibration which terminates with the dispersal in all directions of the zoöspores. No sexual reproduction or resting structures were observed.

#### RELATIONSHIPS

In its type of non-sexual reproduction and superficial aspect within the eggs, this organism resembles *Myzocytium zoophthorum* Sparrow (3). This is particularly true when more than one thallus develops in a single egg. In such cases a marked resemblance to figure 8, plate 19 of *M. zoophthorum* is apparent. However, no septation of the thallus was ever found in the numerous examples studied, and it remained one celled throughout. Indeed, where only a single thallus took possession of an egg, and where presumably, because of the large amount of available food and space, unlimited development could take place, only broad lobes were formed. One and two celled thalli of *Myzocytium proliferum* Schenk have been figured by Zopf (5) but these are obviously non-typical, aberrant forms. Evidences for a multicellular development were searched for in particular in the egg parasite but none was found.

Comparison with the remarkable Copepod parasite *Oovorus copepodorum* Entz (1) cannot be made, since from the account given of the fungus, no intramatrix vegetative body is described.

The rotifer egg parasite resembles to a marked degree *Lagenidium Oedogonii* Scherffel (2). In this algal parasite, an irregularly ovoid or sac-like or occasionally tubular thallus develops which often forms in fully mature examples broad finger-like lobes. Eventually, the whole structure is converted into a single sporangium the contents of which, after a series of vacuolate stages essentially like those in the present fungus, are discharged through a single (rarely two) evacuation tube. Typically, the zoöspores complete their maturation at the orifice of the discharge tube and in some instances at least, are surrounded by an evanescent vesicle. Scherffel has also observed in what he considers the same species that in rare cases the spores undergo a period of swarming within the sporangium and then emerge individually to form as in *Achlya*,

a group of motionless cysts at the mouth of the discharge tube. Resting spores, produced by a sexual process similar to that of *Olpidiopsis* have also been observed by Scherffel. No well defined fertilization tube, such as is ordinarily formed for example in *L. Rabenhorstii* is developed and in this feature it approaches most species of *Olpidiopsis*.

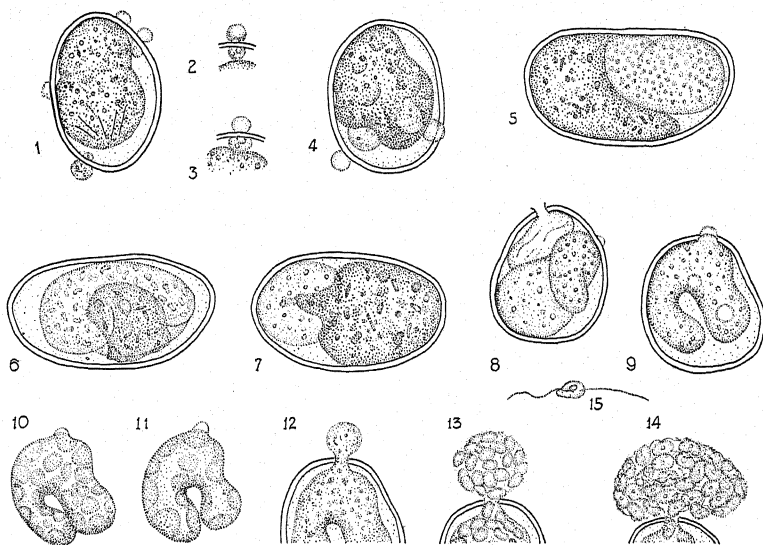
*Lagena radiculicola* Vanterpool and Ledingham (4) a parasite of wheat roots, exhibits a one-celled body plan essentially similar to the rotifer egg parasite and *Lagenidium Oedogonii*. Like the last named, it remains attached to the host wall at the point of infection during its development, a ring of host wall material being produced which aids in maintaining this connection. Further, the method of zoöspore formation, the zoöspores, type of sexual reproduction and oöspores differ in no essential features from one-celled species of *Lagenidium*. *Lagena* does differ however from *L. Oedogonii* in that (1) the point of attachment of the parasite is also the place of formation of the discharge tube of the sporangium and (2) in sexual reproduction a definite antheridial tube is produced by the male thallus which makes contact with the receptive structure. It should also be noted that in *Lagena* the two conjugating bodies are of equal size whereas from what little is known of *L. Oedogonii* the male is smaller than the female.

It seems evident therefore, that no great morphological differences separate the one-celled algal inhabiting species of *Lagenidium* from the parasite of wheat roots, *Lagena*, or from the parasite of rotifer eggs. All agree in having a one-celled, sac-like lobed or tubular thallus which becomes converted into a single sporangium. Typically, all discharge their laterally biciliate zoöspores in *Pythium*-like fashion and, where sexual reproduction is known, this is by conjugation of thalli. While an antheridial tube is formed in *Lagena*, in contrast apparently to *L. Oedogonii*, this may be so reduced, if the gametes are in contact, as to be only a slight swelling.

Since recent investigations clearly indicate that there are one-celled species of lagenidiaceous organisms which are typically one-celled, and are not so because of poor environmental conditions as Zopf's earlier work indicated, the advisability of segregating

them from *Lagenidium* arises. *Lagena*, with a few slight changes, would readily accommodate them and in the future such a course may prove highly desirable. Further investigations on the process of sexual reproduction in these one-celled forms are necessary, however, before such a change should be made.

Since the parasite of rotifer eggs appears distinct in the shape and size of its sporangium, size of its zoöspores and perhaps physiologically as well from other one-celled lagenidiaceous fungi, it is considered a new species, *Lagenidium oophilum*, or, if *Lagena* ultimately becomes a repository for these organisms, *Lagena oophila*.



FIGS. 1-15. *Lagenidium oophilum*.

***Lagenidium oophilum* sp. nov.**

<sup>3</sup> Thallus aut singulus, irregulariter saccatus vel ellipsoidealis lobatusque, lobis crassis longitudine variantibus, aut thalli aggregati subregulariter ellipsoideales plerumque non lobati, holocarpice transformati in singula sporangia hyalina 20-40  $\mu$  longa, 12-25  $\mu$  lata, cum papilla brevi 4-5  $\mu$  diam. sessili vel paululum producta praedita; zoosporis forma seminibus Vitis generis similibus, lateraliter biciliatis, 8  $\mu$  longis, 6  $\mu$  latis, singillatim ejectis sed gragatim ad tubi os maturantibus, ut videtur a vesciculis non circumdatis; cystospora 5-6  $\mu$  diam. Reproductionem sexualem non vidi.

<sup>3</sup> I am indebted to Prof. H. H. Bartlett for the preparation of the Latin description.



Parasiticum, in ovis embryonibusque rotiferorum, in flumine "Huron" prope urbem Ann Arbor, Michigan, Maio 1937.

Thallus when occurring singly somewhat irregularly saccate or ellipsoidal, with broad lobes of varying length, when several, more regularly ellipsoidal and often unlobed; converted holocarpically into a single thin walled, colorless sporangium 20–40  $\mu$  long by 12–25  $\mu$  wide with a short sessile or slightly prolonged discharge papilla 4–5  $\mu$  in diameter; zoöspores grape seed-like, laterally biciliate, 8  $\mu$  long by 6  $\mu$  wide, discharged individually and undergoing a period of maturation in a group at the orifice of the discharge tube, apparently not surrounded by a vesicle; cystospore 5–6  $\mu$  in diameter; sexual reproduction not observed.

Parasitic in eggs and embryos of rotifers, Huron River near Ann Arbor, Michigan, May 1937.

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#### EXPLANATION OF FIGURES

Fig. 1, Rotifer egg with several encysted zoöspores of *L. oophilum*. Penetration of the egg has been accomplished in two instances; 2, 3, stages in infection of the egg; 4–7, thalli in various stages of development; the darker plasma of the host is gradually being absorbed; 8, egg with a lobed thallus and an empty, unlobed, sporangium; 9, nearly mature thallus; 10, 11, vacuolate stage of sporangium just before discharge; 12, beginning of zoöspore discharge; 13, later stage of discharge; 14, discharge nearly completed, the first emerged zoöspores maturing their cilia; 15, free swimming zoöspore. All figures  $\times 560$ . Figures inked in by Richard Higgins.

## PHOTOGRAPHS AND DESCRIPTIONS OF CUP-FUNGI—XXXIV. A NEW HUMARINA

FRED J. SEAVER

(WITH 1 FIGURE)

During the latter part of November and early December, 1938, the writer had the privilege of making a third visit to Bermuda in continuation of the explorations of the mycoflora of those islands. Among the outstanding species of fungi collected was one belonging to the above named genus. It was unusual in that it seemed to be restricted entirely to the seeds of a cultivated palm, while most of the other species of the genus occur on humus or decaying material of various kinds. Like some other species of the genus it is attractive because of its rather brilliant color. It differs so much from any known species of the genus that the writer is here offering it as new to science. The description is as follows:

### ***Humarina Waterstonii* sp. nov.**

Apothecia occurring singly or in cespitose clusters, sessile or subsessile, early expanding and becoming shallow cup-shaped or subdiscoïd, reaching a diameter of 4–5 mm., externally whitish; hymenium slightly concave, bright red, almost scarlet; asci cylindric or subcylindric, reaching a length of  $300\ \mu$  and a diameter of  $16\ \mu$ , tapering below into a stem-like base 8-spored; spores 1-seriate ellipsoid, slightly narrowed toward either end densely filled with oil-drops and granules, smooth, hyaline about  $14\text{--}16 \times 24\text{--}26\ \mu$ ; paraphyses about  $2\ \mu$  in diameter gradually enlarged above to  $4\ \mu$ .

Apotheciis sparsis aut caespitosis, sessilis vel subsessilis cupulatis vel subapplanatis, 4–5 mm. diam.; hymenio leniter concavo, rubro; ascis cylindricis, octosporis  $300 \times 16\ \mu$ ; sporis monostichis, ellipsoideis, multiguttulatis, levibus,  $14\text{--}18 \times 24\text{--}26\ \mu$ ; paraphysibus clavatis  $2\text{--}3\ \mu$  diam.

On partially buried seeds of *Livistona chinensis*.

This species is dedicated to Mr. J. M. Waterston, the local pathologist in the Experiment Station at Bermuda, in recognition

of his loyal coöperation and the many courtesies extended to the writer on his recent visit to Bermuda. The species was found to be abundant on the seeds of the Chinese palm, *Livistona chinensis*, in cultivation close to the laboratories of the Experiment Station.

#### SPORE DISCHARGE

The present species offers a fine illustration of what might be called a "pop-gun" method of spore discharge, described in the North American Cup-fungi, pages 20 and 21. From the accompanying illustrations, all of which were made with the aid of a camera lucida, the great discrepancy between the size of the ascostome, indicated by the diameter of the operculum, as compared with the diameter of the spore which has passed through the ascostome is quite apparent. The operculum is scarcely half the diameter of the spore. This means that in passing through the ascostome it is necessary for the spore to stretch this opening to twice its original diameter. When the spore has passed half way through it will naturally contract and pop the spore out with accelerated force. That this stretching and contracting has taken place is evident from the fact that the ascostome is always intact after the spores have passed through. The force which drives the spore through the ascostome is supplied by the osmotic pressure within the ascus. Sometimes the force seems to be expended before all of the spores have been discharged and, as shown in the upper right hand figure, occasionally a spore is caught in the very act of "nosing" its way through the ascostome. This theory does not imply that there is any considerable pause between the discharge of each individual spore. They must proceed in single file, but are usually discharged in one continuous series, and apparently at one time, except that occasionally as indicated above the force is not sufficient to drive all the spores through the narrow trap-door which nature has provided for their exit.

This species has some characters in common with those of the tropical genera *Cookeina* and *Phillipsia*, especially the relatively small size of the ascostome. The eccentricity of the ascostome, which seems to be a constant character in those forms, is not so

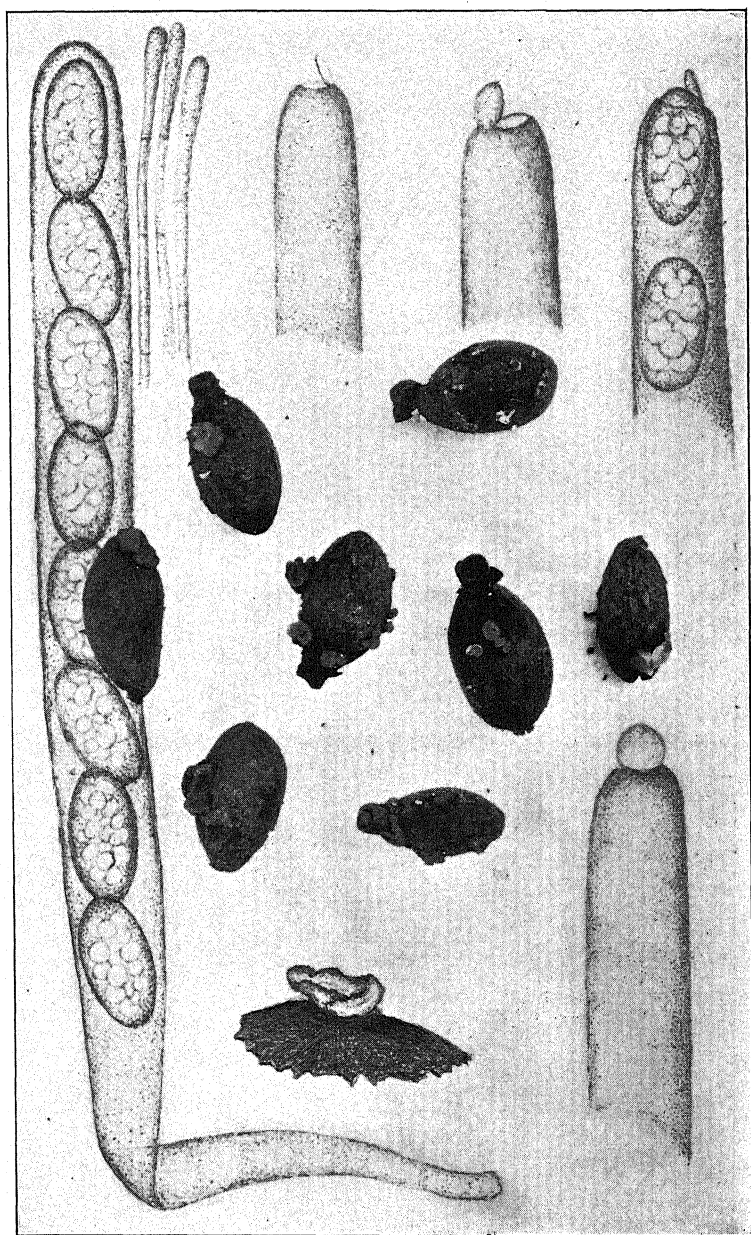


FIG. 1. *Humarina Waterstonii*.

in the Bermuda species, although at times it is more or less eccentric.

THE NEW YORK BOTANICAL GARDEN

#### EXPLANATION OF FIGURE

Center, photo of several infected seeds slightly enlarged; left, an ascus with spores and paraphyses greatly enlarged; upper right, an ascus which had discharged all of the spores except two, one of which has its nose through the ascostome; below center, sketch of two apothecia enlarged; also three views of empty asci showing the ascostome and operculum from different angles.

## TWO NEW FUNGI ON LEGUMES

L. R. TEHON

(WITH 6 FIGURES)

Continued field examination of crops brings to light from time to time, in obviously parasitic rôles, fungi that appear not to have been observed previously. These newly discovered parasites usually do not have, and may never have, large importance. Yet with other minor pests they contribute measurably to the reduction of yields by disease; and on crops such as legumes, which have value as soil builders, they exert an indirect and intangible influence concerned with more than yield alone. As causes of disease the two fungi described here, one injurious to alfalfa leaves, the other a destroyer of Korean lespedeza plants, affect yield but little; their importance lies, rather, in their effect on the vigor of plants relied on to improve soil.

### PLACOSPHERA ON ALFALFA

During the growing seasons of 1935, 1936, and 1938 an alfalfa leaf disease was found, the general appearance of which suggests the familiar tarspot of maple (FIG. 1). Leaflets become infected at one or more points, most commonly, however, only on one side of the midvein. The invaded portion of the blade turns yellow and then collapses between the veins, and the leaf surface assumes a finely corrugated appearance. Distal to the infection the blade shrivels and tends to crack and fray. Later, small areas within infected regions turn black; and the blackening spreads until, in some instances, it occupies nearly half the side of a leaflet. Blackening takes place simultaneously on both the upper and lower surfaces, and as it progresses an abnormal thickening of that part of the blade occurs. In mature material the blackened surfaces are broken irregularly by roundish or fissured openings large enough to be visible under a 10 × magnifier.

Microtome sections reveal (FIGS. 2, 3) that within and near the blackened areas all of the leaf tissues, except the cuticles and the woody cells of the veins, have been destroyed and have been replaced by a compact stroma. Internally, the stroma is a hyaline plectenchyma; but next to the cuticle on each side (FIG. 3) lie one to several layers of more robust, less closely compacted dark-walled cells. Beyond the blackened area less destruction of the leaf tissues has occurred, and the stroma is less perfectly formed.

Spore-bearing cavities (FIG. 4) develop within the stroma and open through either the upper or the lower leaf surface but not through both. Morphologically, these cavities are simple locules; but two or more, merging during development, may appear as a compound locule. They are not sharply differentiated from the stroma; there is only an abrupt transition from the surrounding plectenchymatic cells to conidiophores. Spores are borne apically on the conidiophores and issue in cirrhi from the locule openings. True ostioles are not formed; but, because of the smallness of the openings and the relative permanence of the stromatic rind, the locules are more logically considered as immersed pycnidia than as acervuli.

In classification, this fungus is to be allied with the genus *Placosphaeria*. In 1904 Sydow<sup>1</sup> described *Placosphaeria Lupini* on *Lupinus sparsiflorus* Benth. from Eldorado County, California; but in 1922 he and Petrak<sup>2</sup> transferred the lupine fungus to *Stictochorella*, in which the stroma is superficial, after examining material on living leaves of *Lupinus ornatus* Dougl. from the state of Washington. Since now no authentic species of *Placosphaeria* is recorded on any legume, it is necessary to name the alfalfa parasite as follows:

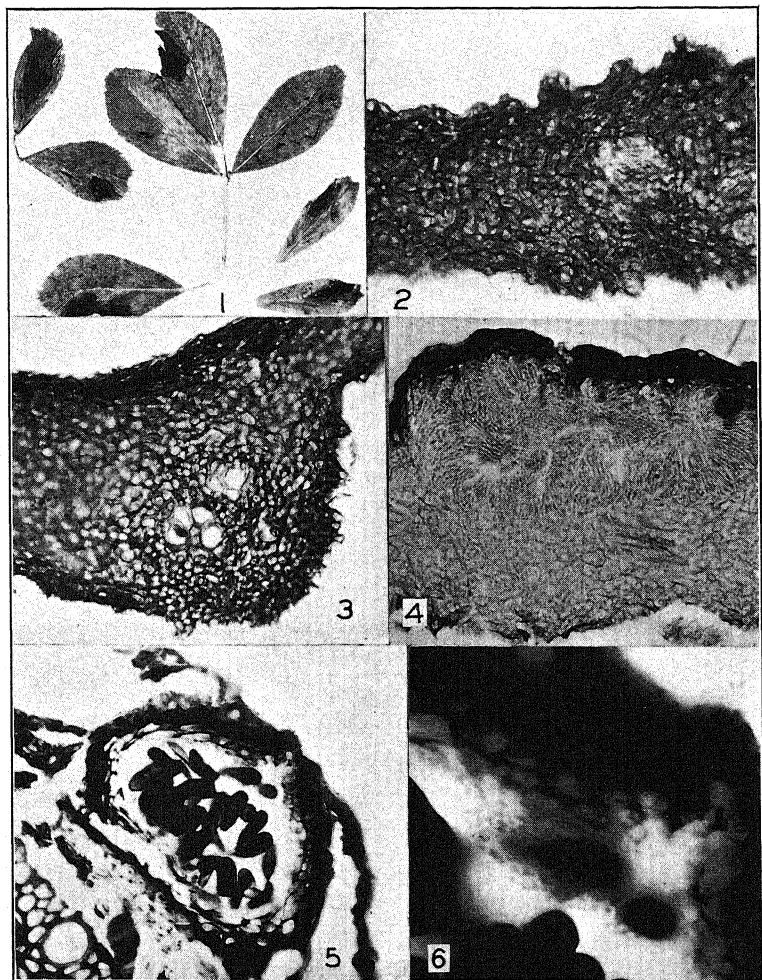
***Placosphaeria Medicaginis* sp. nov.**

Stromatibus in foliis innatis, nigris, variabilibus et irregulariter effusis, rarius confluentibus, tantum 1 cm. longis, multilocularibus; loculis numerosis, amphigenis, sphaericis vel deplanatis, plerumque simplicibus vel saepe confluentibus et apparentibus compositis, 75–140  $\mu$  latis, 75  $\mu$  altis, spurie ostiolaris; sporulis oblongis, hyalinis, continuis, 3–7  $\mu$  longis, 1.5–2  $\mu$  latis.

<sup>1</sup> Sydow, H. & P. Novae fungorum species. Ann. Myc. 2: 162–174. 1904.

<sup>2</sup> Sydow, H. & F. Petrak. Ein Beitrag zur Kenntnis der Pilzflora Nordamerikas, insbesondere der nordwestlichen Staaten. Ann. Myc. 20: 178–218, 1922.

On *Medicago sativa* L.<sup>3</sup>—Freeburg, St. Clair County, Illinois, October 22, 1935, Accession No. 25,276 (type); Malta, DeKalb



FIGS. 1-4. *Placosphaeria Medicaginis*; 5-6, *Catosphaeropsis caulivora*.

County, Illinois, July 17, 1936, Accession No. 26,977; Centralia, Marion County, Illinois, April 29, 1938, Accession No. 26,704.

<sup>3</sup> Collections and field notes were made by G. H. Boewe. Accession numbers designate specimens in the Mycological Collection of the Illinois Natural History Survey.



The three records of occurrence, made, as appears from the above, in different years and in fields separated by as much as 250 miles, indicate a wide distribution for the fungus. In the St. Clair County field 40 among 100 counted plants bore diseased leaves; and on these plants 33 out of 300 leaves, or 11 per cent, were diseased as illustrated. In the DeKalb County field 42 per cent of the counted plants bore the disease; and on these plants 27 among 894 leaves, or about 3 per cent, were infected. And in the Marion County field 94 per cent of the counted plants bore diseased leaves; and 78 among 300 examined leaves, or 26 per cent, were infected.

#### CATOSPHAEROPSIS ON KOREAN LESPEDEZA

Increased planting of Korean *Lespedeza* for soil improvement during recent years has focused attention on the diseases that attack it, and in 1937 the stem blight here described was discovered.

On stems of still living plants lesions first appear between the nodes as elongated areas slightly darker in color than the normal reddish-brown of the stem. Lateral branches show similar but correspondingly smaller lesions, and are soon killed. Eventually all parts of a plant that lie beyond a stem lesion die. As lesions extend and develop, they become dotted with minute black pycnidia, which often are arranged rather definitely in longitudinal rows. At about the same time, the leaves wither and fall off. The stipules wither and die, also, but remain on the stem; and the presence of the disease in advanced stages is grossly signalized, in the field, by the sight of leafless stems and branches clothed in dry, yellow stipules.

In microtome sections of diseased stems mycelium is seen chiefly in three regions: in the cortical collenchyma and parenchyma, between the epidermis and the sclerenchymatic pericycle; in the phloem, cambium, and newest xylem, between the pericycle and the lignified xylem; and in the hollow center of the stem, from which the pith and primary xylem have disappeared.

In the first of these regions hyphae penetrate between and into the cells, kill them, and bring about such disintegration that, in the vicinity of pycnidia and often elsewhere, hardly a vestige of the original tissues can be seen. In the cambial region hyphae bring

about complete destruction of the phloem and cambium and partially dissolve the outer, less lignified cells of the xylem; and finally complete separation of the outer tissues from the xylem occurs. And in the hollow pith hyphae form a loose layer on the inner face of the xylem, where they destroy the remnants of pith parenchyma and primary xylem.

There is, also, direct connection between these layers of mycelium. Since the pericyclic sclerenchyma is not a continuous band, hyphae penetrate to the cambium by way of the parenchyma that intervenes between bast masses, killing and disorganizing the parenchyma cells among which they pass. And hyphae extend by way especially of the vascular rays, but also by way of other xylem cells, from the cambial region to the pith.

The pycnidium (FIG. 5) develops as an inverse structure, in connection with the mycelial plate between the cuticle and the pericycle. At maturity it is somewhat more than hemispherical, with an incomplete base closely affixed to an underlying sclerenchyma bundle. Its wall is membranous and is composed of three or four layers of cells. The cells of the outer two layers are roundish, heavy-walled, brown, and 10–15  $\mu$  in diameter, while those of the inner layers are more elongated, thin-walled except for slightly thickened corners, and less conspicuously brown-tinted. At its apex the pycnidium is at first thickened and raised into a low papilla, as if a true ostiole were being formed; but the papilla eventually breaks or is forced off, leaving an irregularly circular opening for the emission of spores. The sporogenous hyphae (FIG. 6), instead of lying at the base of the pycnidium, line its dome; and the spores cut off from the conidiophores of this layer are brown, oblong, and single-celled.

Although superficially this fungus presents the characters of *Sphaeropsis*, and might be so classified if not fully examined, the incompleteness of its pycnidium and its upside-down method of sporulation place it definitely in the Leptostromataceae; and in this family it seems capable of placement only in the Pycnothyriace of Diedicke.<sup>4</sup> This relationship is supported also by a character of the mycelium. Although the hyphae in the interior of the host are essentially cylindrical, those next to the cuticle frequently form

<sup>4</sup> Diedicke, H. Die Leptostromataceen. Ann. Myc. 11: 172–184. 1913.

plate-like masses intimately connected with the wall of the pycnidium; and in these plates surface filaments present that peculiar structure, termed "radiate" or "aliform," that is recognized as a prominent characteristic of the Hemisphaeriales.

Since it may reasonably be supposed that many of the named species of *Sphaeropsis* also have the characteristics described for this new fungus, it might be thought that the most convenient disposition would be to include it in that genus; but the writer believes that, for accuracy in classification, recognition in the Leptostromataceae of the characters presented by this fungus is desirable.

### **Catosphaeropsis gen. nov.**

Genus Leptostromatacearum cum sporulis brunneis, magnis, et continuis ut in Sphaeropside; pycnidiis membranaceis, hemisphaericis, basim non completis; stratis sporogenibus in fornicibus pycnidiorum sitis; et hyphis extimis radiantibus vel cellas aliformes exhibentibus.

### **Catosphaeropsis caulivora sp. nov.**

Pycnidiis in caulibus, sparsis vel saepius in serie longitudinali ordinatis, conspicue pertusis, 120–200  $\mu$  diametris, atronitidis et cuticula solim indutis sed in regione corticis delapsi nutriticis evolventibus, plusquam hemisphaericis et basim incurvisculis, in apice primitus papilla clausis sed in maturitate poro irregulariter circulari usque 25  $\mu$  diametro evacuantibus; muris membranaceis, non carbonaceis; stratis conidiferis superne in fornice epigentibus; conidiis brunneis, continuis, oblongis usque ovatis vel basim angustis, 16–27  $\mu$  longis, 9–12  $\mu$  latis; hyphis subcuticularibus hyalinis usque brunneis, abunde septatis, in schedis radiantibus vel aliformibus conniventibus.

On *Lespedeza stipulacea* Maxim.—Crossville, White County, Illinois, July 22, 1937, Accession No. 26,978 (type); Metropolis, Massac County, Illinois, September 9, 1937, Accession No. 26,979.

The importance of this fungus in the two fields in which it has been observed is indicated by the notes accompanying the two collections. In the field from which the type material was taken, a count of 1000 plants showed that only 0.1 per cent were diseased; but in the other field, examined a month and a half later, 11 per cent of the plants were diseased.

SECTION OF APPLIED BOTANY AND PLANT PATHOLOGY,  
THE ILLINOIS NATURAL HISTORY SURVEY,  
URBANA, ILLINOIS

## EXPLANATION OF FIGURES

Figs. 1-4. *Placosphaeria Medicaginis*. 1, alfalfa leaflets showing various degrees of infection and bearing the black stromata typical of the fungus; 2, section through a young part of a stroma, illustrating the nearly complete dissolution of leaf tissue; 3, section through the mature portion of a stroma, illustrating the destruction of all but the cuticles and woody vein-cells of the leaf, and the development of the stromatic rind; 4, section through a mature stroma, showing two epiphyllous sporiferous locules that merged during development.

Figs. 5-6. *Catosphaeropsis caulivora*. 5, a section, not quite vertical, through a pycnidium, illustrating the incomplete base (torn loose from the sclerenchyma), characteristics of the wall and the spores, and the absence of a basal sporiferous plectenchyma; 6, inner wall, in section, near the top of a pycnidium, illustrating the location of the sporiferous layer in the dome of the pycnidium.

## STUDIES IN THE PURPLE-BROWN SPORED AGARICS<sup>1</sup>

ALEXANDER H. SMITH

(WITH 6 FIGURES)

During the past five or six years considerable attention has been given to the fragile purple-brown spored agarics of Michigan, but, due to confusion in the literature both in America and abroad, progress in identifying the collections has been slow. Because of this confusion, I have limited myself largely to interpretations of American species based on studies of the type collections, and have not found it advisable to attempt to make critical comparisons of American with European species. In *Psathyra stipitissima* and *Psathyrella subatrata*, however, such comparisons have been necessary.

I wish to express my thanks to Prof. H. M. Fitzpatrick of Cornell University, Ithaca, New York, for the opportunity to study Atkinson's collections and for the photograph of *Hypholoma confertissimum* Atk.; to Dr. H. D. House of the New York State Museum, Albany, N. Y., who very kindly placed Peck's collections at my disposal, and to Dr. F. J. Seaver of the New York Botanical Gardens, New York City, for access to the types of the species described by Dr. W. A. Murrill. All color names within quotation marks are taken from R. Ridgway, *Color standards and color nomenclature*, Wash., D. C., 1912. The collection numbers are those of the writer unless otherwise stated. The specimens have been deposited in the University of Michigan Herbarium.

PSATHYRA MICROSPERMA Peck, PSATHYRA MULTIPEDATA Peck,  
PSATHYRA STIPITISSIMA Lange and HYPHOLOMA CONFERTISSIMUM Atk.

*Psathyra microsperma* and *P. multipedata* have been reported and illustrated for Michigan (1) (7). My determination (7) of the former species was based on a collection made near Ann

<sup>1</sup> Papers from the University of Michigan Herbarium.

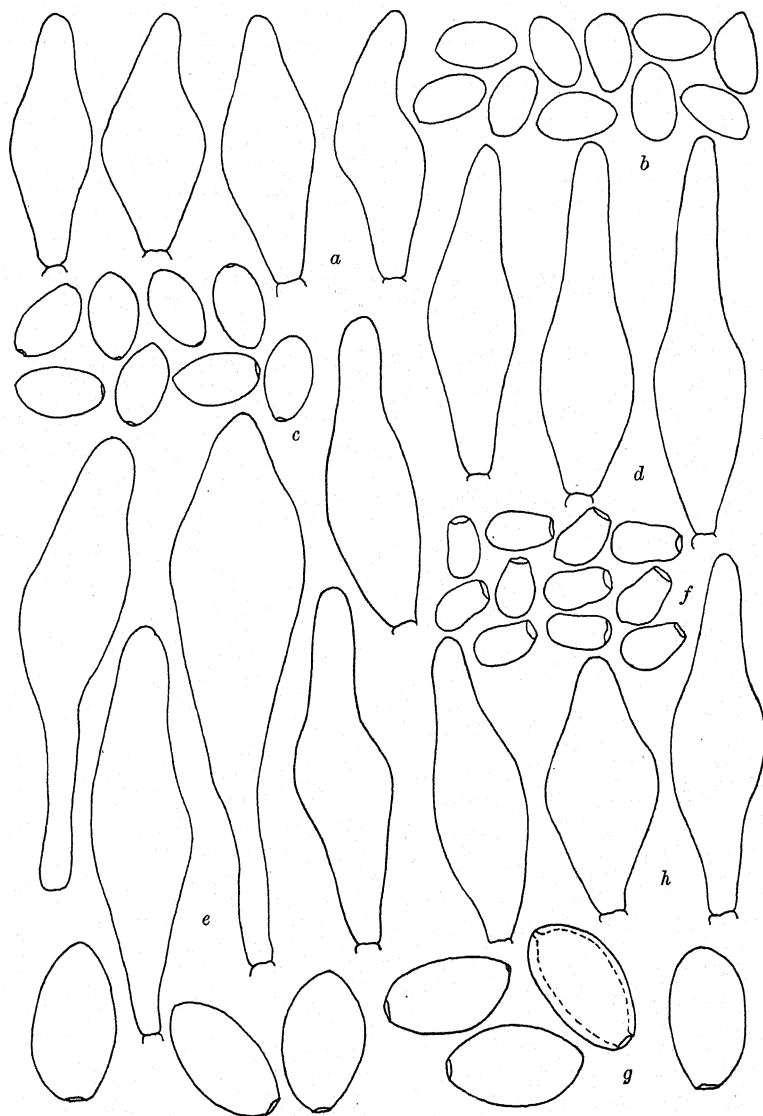


FIG. 1. a, b, *Psathyra microsperma*; c, d, *Psathyra multipedata*; e, g, *Psathyra umbonata*; f, h, *Hypholoma confertissimum*.

Arbor in 1905 by Kauffman and identified as *P. microsperma* by Peck himself. Kauffman first reported the species for Michigan using this collection as the basis of his report. During the past year I have had occasion to study the types of both *P. multipedata* and *P. microsperma* with the result that a critical review of all the species mentioned above has been made necessary.

*Psathyra microsperma* Peck (FIG. 1, *a, b*).—The type specimens of this species are rather badly broken up and not preserved in compact clusters. They give one the impression of a cespitose fungus in which the bases of the clusters are at best only loosely held together as in large bunches of *Hypholoma hydrophilum*. I found no evidence of a pseudorhiza. Due to the condition of the collection, however, the possibility that such a structure was present is not excluded. Pleurocystidia and cheilocystidia are similar and quite abundant. They measure  $23-36 \times 10-15 \mu$ , and are tapered to a subacute apex above an inflated midportion. Their walls are thin and hyaline. The basidia are four-spored. The spores measure  $6.5-8 \times 4-4.5 \mu$ , are ellipsoid, dull reddish-brown in dilute KOH under the microscope, and have a slightly flattened apex but *no distinct hyaline germ pore is visible under a 1.25 N.A. oil immersion lens*. The pileus-trama did not revive well, but appeared to have the layer of hyaline inflated cells over the surface which is characteristic of nearly all species of *Psathyra*.

The type of *Psathyra multipedata*, as Murrill (3) has pointed out, is in excellent condition. It consists of clusters of fruiting bodies, and a pseudorhiza projects from the base of the best preserved cluster. The microscopic characters are as follows: The spores measure  $6.5-8 \times 3.5-4 \mu$ , are dull reddish-brown when mounted in dilute KOH, ellipsoid, and when viewed under an oil immersion lens are seen to be furnished with a *very distinct* hyaline apical germ pore giving the apex of the spore a truncate appearance. Pleurocystidia were found only near the edges of the lamellae and were similar to the cheilocystidia. The latter are very abundant and measure  $35-46 \times 9-13 \mu$ . They are hyaline, narrowly fusoid with somewhat tapered apices, smooth, and have very thin walls. The pileus-trama is covered by a layer of somewhat elongated, inflated hyaline cells as previously illustrated, Smith (7). The cystidia and spores of the type are shown in figure 1, *c* and *d*.

*Hypholoma confertissimum* Atk. (FIG. 1, f, h).—This species was described in 1918 along with *H. comatum*. Parker (5) in his monograph of *Hypholoma* excluded *H. comatum* from the genus because he did not see the type. He failed to mention *H. confertissimum*. This situation is rather difficult to understand since the type specimens of both species can be readily located by their collection numbers in the Atkinson Herbarium at Cornell University. Atkinson suggested that *H. confertissimum* was related to *Hypholoma aggregatum* Peck. An examination of Atkinson's type also shows its relationship to *Psathyra multipedata* in the presence of a pseudorhiza and the characteristic cespitose habit which the species exhibits as a result. The microscopic characters of the species are as Atkinson briefly described them. In addition, I found the pileus-trama to be covered by a surface layer of hyaline inflated cells several cells deep. The pleurocystidia and cheilocystidia are abundant,  $30-48 \times 10-16 \mu$ , and are narrowly to broadly fusoid with subacute apices. The spores are quite distinctive and serve to separate the species readily from both *H. aggregatum* and *P. multipedata*. They measure  $5-6 \times 3-3.5 \mu$  and possess a hyaline apical germ pore which is much broader than in the spores of either of the other two. Figure 1, f, also shows a characteristic difference in shape.

In all of the Michigan collections identified as *P. microsperma*, including the one determined by Peck, the spores are furnished with a distinct hyaline germ pore. The cystidia are similar in shape and distribution to those of *P. multipedata*, but are readily located on the sides of the gills. The characteristic pseudorhiza of *P. multipedata* is present in my no. 33-1116 which was previously determined as *P. microsperma*. In Kauffman's material the manner in which the soil was cut away around the specimens prevents this character from being accurately determined. It is evident in one cluster, however, that not all of the base was obtained since the cut stems are visible underneath. Apparently his specimens were found growing in very hard compact soil.

If only the type specimens are considered, *P. microsperma* differs from *P. multipedata* in the spores which lack a characteristic hyaline germ pore when viewed under an oil immersion lens, in the more abundant pleurocystidia, and by the fragile nature of



the pileus as is evidenced by its failure to revive as well when sectioned and mounted in KOH. Macroscopically, according to the original descriptions, the former differs from the latter in having veil remnants at first scattered over the pileus, in the shorter stipes and apparently in the looser clusters formed by the fruiting bodies.

In my estimation the difference in the germ pore in the spores of the two species is sufficient to justify their recognition at least until a future study demonstrates that the character is not constant. Using this character as a starting point, all previously reported Michigan collections of *P. microsperma* should be classified under *P. multipedata*. The distribution of the pleurocystidia is a variable character in *P. multipedata*. I have studied abundant material (no. 33-1033; 5018; 5019) from Michigan. In no. 5019 I first described them as absent whereas in no. 5018, collected on the same day in a different locality they were present. These two collections were compared when fresh and found to be identical in every other respect. Later, when reexamining both collections in the herbarium a few cystidia were found on the gill faces of no. 5019. Since the fruiting bodies of this species are exceedingly fragile, it did not seem wise to section from the type indiscriminately to see if a few pleurocystidia could be found scattered farther back from the edges of the gills. The observations cited above for the Michigan collections are regarded as sufficient evidence to establish the sporadic distribution of these organs in this species. The difference in the length of the cystidia of the two species is not, in my estimation, an important character. Obviously additional collections of *P. microsperma* are needed to properly characterize it. The length of the stipe, which Murrill emphasized, is likely to be variable, and the presence or absence of veil remnants is always troublesome. In regard to the pileus-trama, the manner in which the specimens were dried or their condition when collected could readily produce the difference noted. Kauffman (1) emphasized the word glabrescent in his description, which indicates to me that his specimens were already glabrous when collected, and does not raise an objection to their being placed in *P. multipedata*, which often has fibrillose remains of the veil scattered on the stipe.

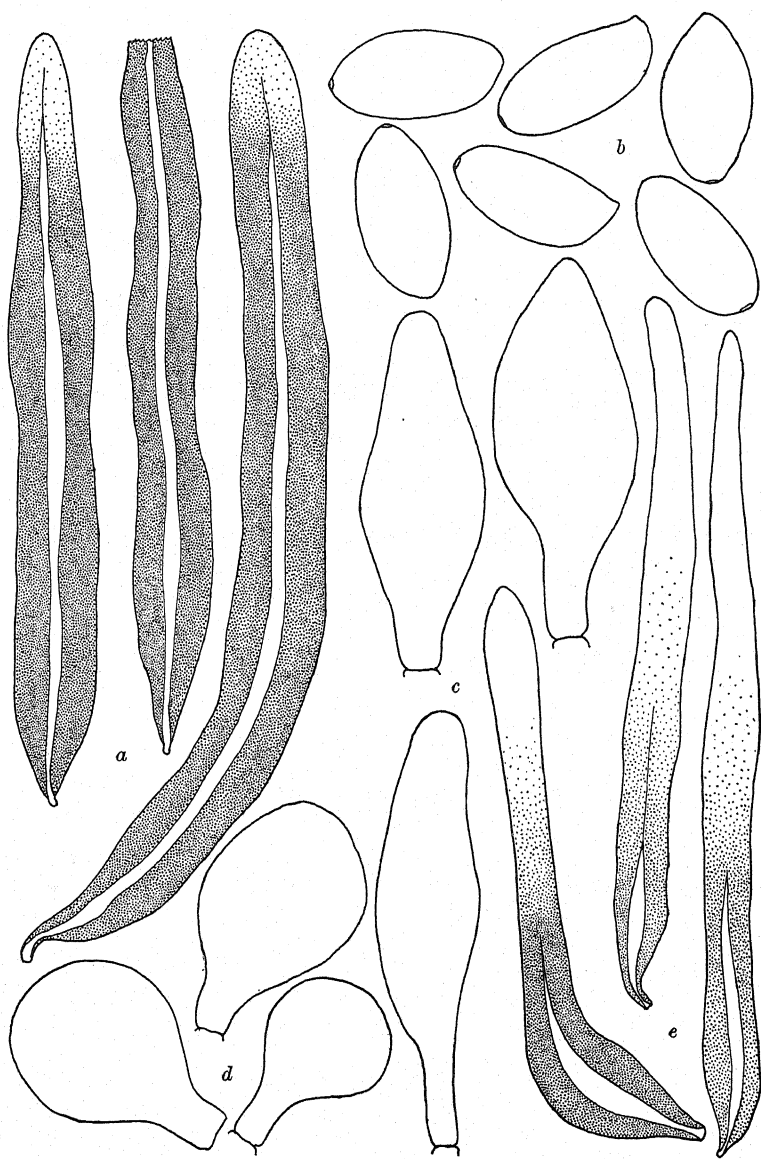


FIG. 2. a-d, *Psathyrella graciloides*; e, *Psathyrella gracillima*.

*Psathyra stipitissima* Lange is clearly a member of this group and can hardly be distinguished from *P. multipedata*. Lange described his species as lacking a veil, and with isodiametric-polygonate cells over the surface of the cap. He apparently described these cells from a surface view rather than from a vertical section through the pileus. He does not give information about the type of germ pore present in the spores. His comments, p. 11 (2), that "The densely stipitate growth distinguishes this species from all other *Psathyras* which individually bear some likeness to it" indicates that he had not considered any of the American species discussed here.

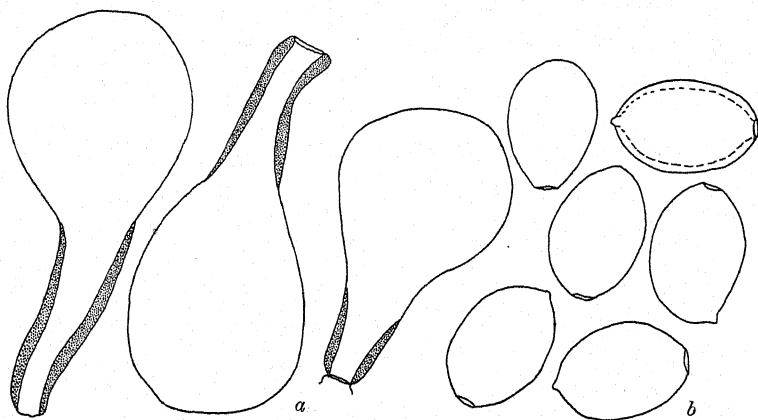


FIG. 3. a, b, *Psathyrella gracillima*.

The following description of *P. multipedata*, drawn from my notes, is given below to facilitate a comparison of it with both *P. stipitissima* and *P. microsperma*:

Pileus 1–4.5 cm. broad, ovoid to obtusely conic, becoming broadly umbonate, convex or nearly plane, surface glabrous, very young buttons (3 mm.  $\pm$  broad) with a thin zone of white evanescent fibrils along the margin, smooth or at times regulose, hygrophanous, "Buckthorn Brown" over all and with a faintly striate margin when moist, lubricous, fading to whitish or dull lead gray along the margin and more or less "Ochraceous-Buff" on the disc; flesh thin and fragile, pallid, odor and taste not distinctive; lamellae close, narrow (3 mm.  $\pm$ ), ascending adnate, whitish, soon sordid purplish-brown, edge even and white fimbriate; stipe 5–10 cm.

long, 2-4 mm. thick, equal, hollow, very rigid and fragile, densely cespitose, the clusters branching from the apex of a long pseudorhiza which arises from a depth of a foot or more beneath the surface (The origin of this structure could not be traced due to mechanical difficulties, but it probably originates on deeply buried roots of elm and ash.), veil remnants slight and either scattered over the lower third of the stipe as white fibrillose flecs or forming a faint subbasal white fibrillose zone, upper two-thirds densely pruinose and often slightly striate; pileus-trama covered by a compact layer of vertically more or less elongated inflated cells; pleurocystidia varying from scattered in some pilei to rare or absent in others,  $34-46 \times 9-14 \mu$ , narrowly flask-shaped; basidia four-spored; spores  $6.5-8 \times 3.5-4 \mu$ , dark purplish-brown in water mounts when fresh, ellipsoid, with a distinct hyaline apical germ pore when viewed under an oil immersion lens.

Figure 4 illustrates the pseudorhiza and the type of cluster which results from this manner of growth. Very often three or four clusters occur very close together and the resulting compound cluster may contain over one hundred pilei. Smith (7), plate XX, illustrated unfaded pilei, and on plate XXI rugulose faded pilei. A comparison of figures 4 and 5 in this report shows at once the relationship between *H. confertissimum* and *P. multipedata*. Although the two species belong in the same genus, no new combination is justified until a revision of *Hypholoma*, *Psathyra*, *Psilocybe* and *Psathyrella* is completed.

*PSATHYRA UMBONATA* Peck (FIG. 1, e, g).

Pileus 1-4 cm. broad, obtusely conic to convex, becoming broadly convex or nearly plane, surface smooth to slightly rugulose, glabrous and moist, color variable, "Ochraceous-Tawny," "Cinnamon-Brown" or evenly "Tawny-Olive" except for the abruptly pallid margin when young, becoming "Dresden Brown," "Snuff Brown," "Sepia" or even "Olive-Brown" before fading, hygrophalous, "Pinkish-Beff," sordid "Cinnamon-Beff" or "Pale Olive-Beff" when faded (the umber colors of the moist cap develop as the spores mature); flesh thin, watery brown, fragile, odor and taste not distinctive; lamellae close but becoming subdistant, 18-22 reach the stipe, short ones in three tiers, bluntly adnate, broad (3-4.5 mm.), pallid to "Pinkish-Beff" when very young, becoming darker brown and finally "Fuscous" or with a purple sheen; stipe 5-8 cm. long, 1-2 mm. thick, strict and cartilaginous, tubular, equal, at first with scattered fibrils from the very rudimentary veil or veil entirely lacking, apex pruinose, soon

glabrous and polished, translucent in age and becoming sordid toward the base, base faintly mycelioid at times; spores  $12-15 \times 6.5-8 \mu$ , ellipsoid with an apical hyaline pore, dark fuscous under the microscope; pleurocystidia rare to scattered, similar to cheilocystidia; cheilocystidia scattered to abundant  $40-60 \times 10-18 \mu$ , inflated toward the middle and with obtuse apices, hyaline; basidia four-spored; pileus-trama corticated by an irregular layer of inflated cells, many of which have a short pedicel.

Scattered to gregarious on sticks and debris, Silver Lake, Dexter, Oct. 1, 1936 (No. 4991), and Sept. 23, 1938 (No. 11042). The spores of the type measure  $12-15 \times 6.5-8 \mu$ , and possess an apical hyaline germ pore. The cheilocystidia are scattered,  $40-60 \times 10-12 \mu$ , thin walled and hyaline. The pleurocystidia are present near the gill-edge and similar to the cheilocystidia. The pileus-trama did not revive well but isodiametric enlarged cells could be seen over the surface. No brown-walled setae were found. Kauffman's account of *P. umbonata* is erroneous. The two specimens in his collections, one obtained by him in 1906 and the other by Baxter in 1920, have the typical brown-walled setae on the surface of the pileus which characterize *Psathyrella subatrata*, and both answer the descriptions of that species in all other respects. Since Kauffman reported the species as infrequent it is logical to assume that he had seen it at least several times, but lacking additional specimens, it is impossible to evaluate his comments further.

PSATHYRELLA GRACILOIDES Peck (FIG. 2, *a, b, c, d*), and PSATHYRELLA GRACILLIMA Peck (FIG. 2, *e*; 3, *a, b*).

During the course of my study of *P. umbonata* and *Psathyrella subatrata*, I have had an opportunity to study the type specimens of *P. graciloides* and *P. gracillima* Peck. Peck's description and illustrations of the former are very suggestive of *P. subatrata*. The following data were obtained from a study of the type: The spores of *P. graciloides* measure  $15-17$  ( $18$ )  $\times 6-8.5 \mu$ , are ellipsoid, blackish under the microscope, and are furnished with an inconspicuous hyaline apical germ pore which gives to the apex a slightly flattened appearance. The basidia measure  $22-24 \times 10-12 \mu$  and are four-spored. Pleurocystidia are present only near the edges of the lamellae and measure  $35-50 \times 10-16 \mu$ . The cheilocystidia are of two types, either similar to the pleurocystidia

or much shorter and saccate, measuring  $20-25 \times 10-15 \mu$ . The pileus-trama is covered by a surface layer of inflated hyaline cells which did not revive well enough in vertical sections of the pileus to allow their shape to be clearly discerned. In addition numerous setae with thick brown walls were scattered over the surface.

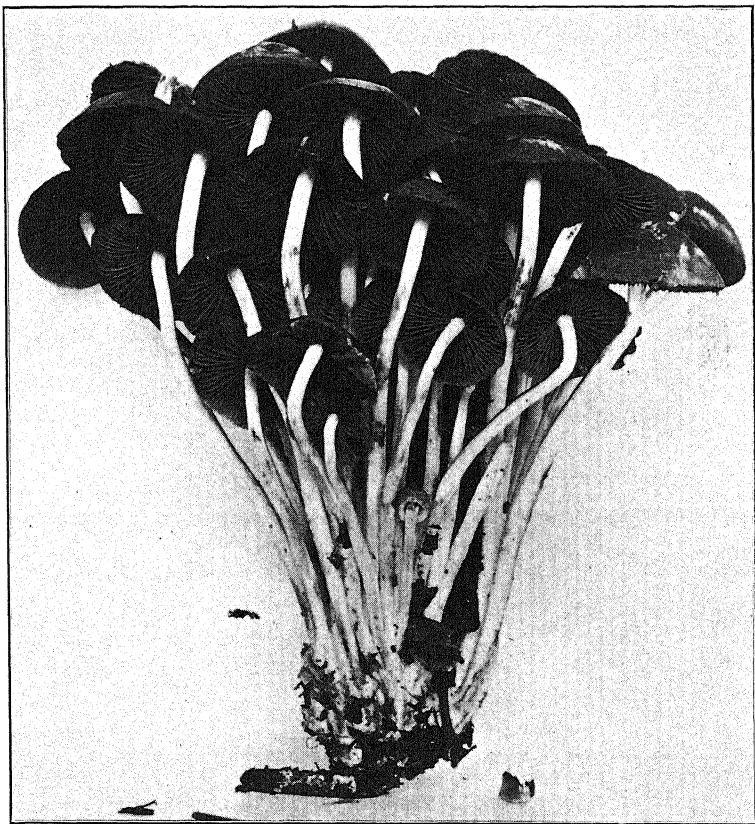


FIG. 4. *Psathyra multipedata* Peck  $\times 1$ .

These measure  $100 \mu$  or more long and  $4-6 \mu$  thick. A comparison of Peck's type both macroscopically and microscopically with specimens of *Psathyrella subatrata* clearly shows that the two are the same. The matted fibrils referred to by Peck (6 p. 43), are undoubtedly the brown-walled setae mentioned above. Peck's name is therefore to be regarded as a synonym of *P. subatrata*.

Apparently the relationship of *Psathyra conopilea* (Fries) Quél. to *Psathyrella subatrata* needs further study, see Lange (2).

*Psathyrella gracillima* Peck seems to be readily distinguishable from *P. subatrata* in its macroscopic characters. Its microscopic characters, however, are also very interesting. The pileus-trama is composed of very broad hyphae, and the surface is covered by a rather loose palisade of clavate cells which have pedicels fre-

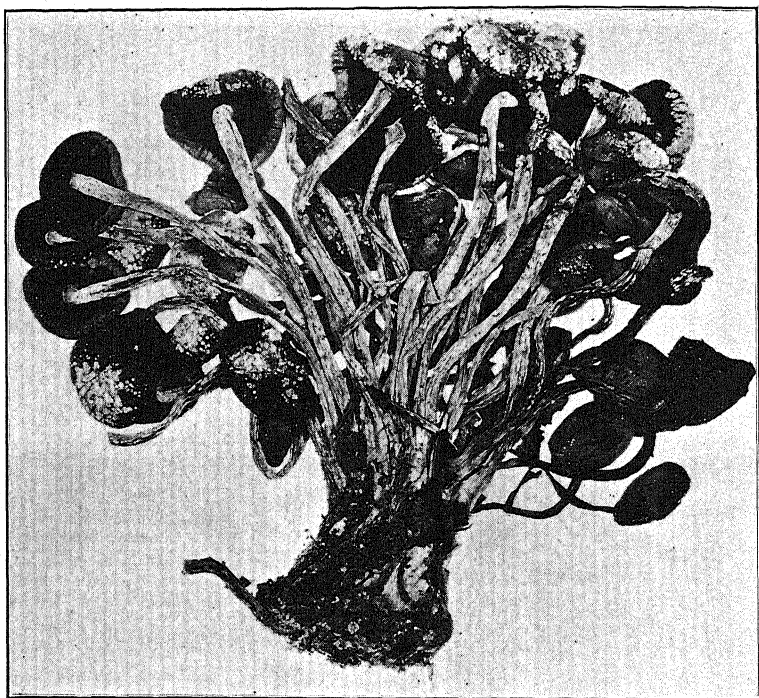


FIG. 5. *Hypholoma confertissimum* Atk.  $\times 1$ . (Type)

quently furnished with brownish somewhat thickened walls. These cells measure  $36-48 \times 14-22 \mu$ . In addition setae are also present. The latter arise from between the cells of the palisade, measure  $80-150 \times 4-7 \mu$ , and are furnished with a thick-walled brownish base. The apical two thirds has more or less hyaline walls which are also thickened. The basidia are four-spored. The spores measure  $12-14 \times 7.5-9 \mu$ , are coal-black under a microscope in KOH, and have a small apical hyaline germ pore.

No cystidia were seen. The hymenium is filled with very broad paraphyses as in species of *Coprinus*, and the manner in which the basidia with sterigmata are projecting is also strongly suggestive of that genus. The pilei of the type are plicate-striate and very delicate in texture.



FIG. 6. *Stropharia annelareiformis*  $\times 1\frac{1}{2}$ .

*STROPHARIA ANNELAREIFORMIS* Murr (FIG. 6).

Pileus 1–3 cm. broad, obtusely conic, becoming campanulate and finally plane, sometimes slightly umbonate and the margin decurved, surface glabrous, viscid, margin faintly striatulate when moist, "Tawny" when young, becoming "Mars Brown," "Cinnamon



Brown" or "Verona Brown" when still moist, subhygrophanous and slowly becoming 'Buffy Brown' in age; flesh thickish, pallid, odor and taste not distinctive; lamellae close, broad, bluntly adnate with a decurrent tooth at times, seceding readily from the stipe, pallid to dull brown when young, finally becoming dark purple-brown, margin whitish and even; stipe 2-8 cm. long, 1-4 mm. thick, pallid tawny, rather coarsely pruinose above the annulus and decorated with fibrillose patches below which give it a whitish appearance at least when young, soon becoming hollow and in age the cavity rather large, often rooting in the manure, pseudorhiza up to 3-4 cm. long in some, base usually white mycelioid; annulus median or superior, membranous and flaring at first, often evanescent; basidia four-spored; spores  $9-12 \times 6-7.5 \mu$ , with a hyaline apical germ pore, broadly ellipsoid in outline, obscurely angular, pale brown in KOH, dark purple-brown in mass; pleurocystidia not differentiated; cheilocystidia narrowly flasked-shaped to clavate,  $25-30 \times 6-12 \mu$ , inconspicuous; pileus-trama homogeneous below a gelatinous pellicle.

Scattered on horse dung, Ann Arbor, July 1, 1933 (No. 33-571). Murrill (3) reports it as known only from the type locality, New Orleans, La., but has recently listed it from Florida in a mimeographed list. My specimens differ from the species as he described it in the usually hollow stipe at maturity, the striate margin of the pileus, the lamellae not being truly decurrent, and in the presence of a rather well differentiated pseudorhiza in some specimens. Since Murrill described the species from rather meagre material and since my collection showed considerable variation in the characters just mentioned, it does not seem wise to describe the latter as a new species. The striations on the margin of the pileus often depend directly on the amount of moisture present in the trama, and since the colors as given by Murrill represent those of somewhat faded fruiting bodies in my collection, I am inclined not to place any significance on these differences. The attachment of the lamellae in *Stropharia* is also a variable character when one is comparing bluntly adnate gills which have a decurrent tooth with gills described as decurrent. The lamellae in broadly expanded pilei of species in which they are bluntly adnate often appear somewhat decurrent due to the way the gill-extremities are raised above a horizontal line. The attachment of the lamellae in Murrill's type appeared to be typical for coprophilous viscid species of *Stropharia*.

The presence of a pseudorhiza in some of my specimens presents a more serious difference, but in view of the small amount of material known, and the irregularity of the character in my collection, it can not be considered important at present. The microscopic characters of the type are identical with those given in the description.

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#### DESCRIPTION OF FIGURES

The drawings of the cystidia, setae and spores were made with the aid of a camera lucida. The cystidia and setae are reproduced at a magnification of approximately 1250 X. The spores are reproduced at a magnification of approximately 1500 X. All of the illustrations were drawn from type specimens.

Fig. 1, *a* and *b*, pleurocystidia and spores of *Psathyra microsperma* Peck; *c* and *d*, spores and cheilocystidia of *Psathyra multipedata* Peck; *e* and *g*, pleurocystidia and spores of *Psathyra umbonata* Peck; and *f* and *h*, spores and cystidia of *Hypholoma confertissimum* Atk. Fig. 2, *a*, *b*, *c* and *d*, setae, spores, pleurocystidia and cheilocystidia of *Psathyrella graciloides* Peck; *e*, setae of *Psathyrella gracillima* Peck. Fig. 3, *a* and *b*, cells from the surface of the pileus and spores of *Psathyrella gracillima* Peck. Fig. 4, *Psathyra multipedata* Peck X 1. Fig. 5, *Hypholoma confertissimum* Atk. X 1 (type). Fig. 6, *Stropharia annellareiformis* Murr. X 1½.

# RECLASSIFICATION OF CHYTRIDIUM SPINULOSUM WITH ADDITIONAL OBSERVATIONS ON ITS LIFE HISTORY

ALFRED F. BARTSCH

(WITH 24 FIGURES)

In the course of an examination of conjugating filaments of *Spirogyra Weberi* Czurda, collected in a roadside ditch near Seymour, Wisconsin, in the early summer of 1938, a rhizidiaceous fungus was found parasitizing the zygospores but not the vegetative cells. Because of its characteristic aculeated zoösporangia and its general habit of growth the organism was recognized as one described by Blytt in 1882 as *Chytridium spinulosum*. Study of the method of zoöspore discharge and the appearance of empty zoösporangia revealed that the apical structure, taken by Blytt to be an operculum of the *Chytridium* type, is actually an apical ornamentation similar in certain respects to the apical spine of *Obelidium*. It plays no part in zoöspore discharge since the spores escape through a sub-apical exit pore. On the basis of this difference it seems necessary to separate this species from *Chytridium* as the type of a new genus. The name *Blyttiomycetes* is thus proposed in commemoration of the man who first collected this interesting fungus.

Since Blytt (1882) was unable to see zoöspore discharge in his material, he concluded from the general appearance and location of the sporangial apiculus that its function was that of an operculum. This, in addition to the intramatrixity of the resting spores, led him to conclude that he was dealing with an undescribed species of *Chytridium*, and he accordingly described the chytrid under the binomial of *Chytridium spinulosum*. The present observations are not the first to show the inoperculate nature of the sporangium; it was recognized by Petersen (1910) since he described its dehiscence by a lateral orifice. It was also recognized later by Scherffel (1926) since he stated clearly that the apical

structure is not an operculum. In addition, he pointed out that the relationship of Blytt's fungus to *Chytridium* is doubtful. During the same year Denis (1926) described what he considered to be germinating resting spores, but his figure, however, suggests that he probably was dealing with mature zoösporangia and ungerminated resting spores in the same host. A brief description of this fungus was given by Cejp (1932). Although all the zoösporangia seen by him were empty, he was unable to find a lateral exit pore but did find a pore located near the apex of the sporangium. He did not see an operculum but maintained that the growth habit of the fungus indicated its systematic position in the genus *Chytridium*.

**Blyttiomycetes** gen. nov.

Thalli partly intra- and extramatrical, monocentric, eucarpic. Zoösporangia extramatrical, globose, inoperculate, provided with an apiculus developing from distal portion of zoöspore case, with subapical exit pore; forming by enlargement of extramatrical spore and delimited from intramatrical portion of thallus by a septum. Zoöspores uniguttulate, uniflagellate. Intramatrical portion of thallus coarse, extensive, consisting of 2, rarely 3, apophyses, the distal one bearing a branched rhizoidal system. Resting spores intramatrical, variable in shape, forming by growth and encystment of an apophysis; germinating by the formation of an extramatrical sporangium liberating zoöspores.

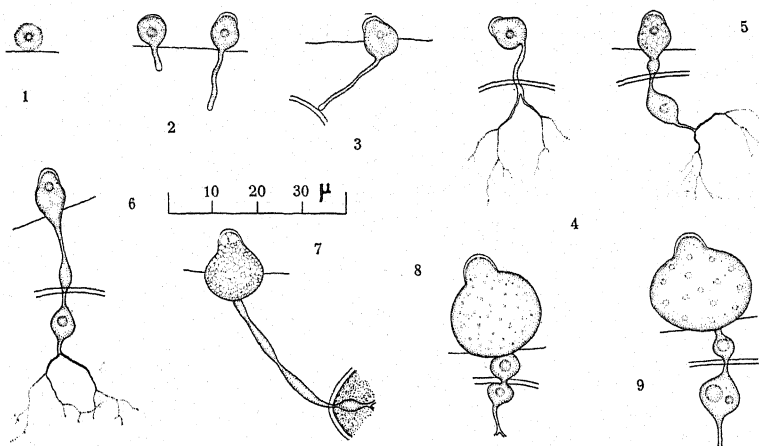
Thalli partim intra- et extramatriciales, monocentriques, eucarpices. Zoösporangia extramatricalia, globosa, inoperculata, apiculata ex distale parte involucri zoösporaе, cum exeunte poro subapicale; formantia augmento extramatricialis sporidii et de parte intramatricale thalli septo definita. Zoösporaе uniguttulatae, uniflagellataeque. Pars intramatricialis thalli, crassa, lata, de 2 rare 3, apophysibus, distale ferente ordinem rhizoideam ramosamque. Quiescentia sporidia, intramatricalia, forma varia, formantia incremento encystmentoque apophysis; germinantia fabricatione extramatricialis sporangii zoösporas liberantis.

**Blyttiomycetes spinulosus** (Blytt) comb. nov.

*Chytridium spinulosum* Blytt, Christiania Vidensk. Selsk. Förh. p. 27. 1882 (no figures).

Zoösporangia multispored, aggregated, globose, inoperculate, hyaline, aculeated,  $14.2\text{--}28.0 \times 16.8\text{--}32.3$ , averaging  $23.4 \mu$  in diameter  $\times 28.2 \mu$  high exclusive of apiculus; with a single lateral exit pore about  $40^\circ$  from apex; aculei narrow, hyaline, about  $0.5\text{--}$

2.0  $\mu$  long, with rounded apices; apiculus cuculate, hyaline, smooth-walled, 5.6  $\mu$  in diameter  $\times$  3.5–4.9, averaging 3.8  $\mu$  high. Zoospores spherical to ovoid, hyaline, 4.2–7.0  $\mu$  in diameter, with a large, clear, refractive globule; flagellum approximately 25  $\mu$  long; zoospore case becoming thickened distally, persisting as sporangial apiculus after germination. Intramatrical portion of thallus coarse, extensive; consisting of 2 tandem apophyses separated by zygo-spore wall of host, rarely with 3 apophyses, and with an extensive, branched rhizoid, up to 3.6  $\mu$  in diameter, extending from distal apophysis, tapering to delicate points. Apophyses spherical, ovoid or spindle-shaped, with smooth, hyaline membrane; proximal apophysis 5.6–7.0, averaging 5.9  $\mu$  in diameter, distal one 4.2–21.1,



FIGS. 1-9. *Blyttimyces spinulosus*.

averaging 11.2  $\mu$  in diameter. Resting spores smooth, spherical, ovoid or irregular, 14.0–32.2, averaging 22.2  $\mu$  in diameter, with 2-layered, hyaline wall 3.0–5.0  $\mu$  thick; endospore 2.0–3.8  $\mu$ , exospore about 1.0–1.2  $\mu$  thick; with finely granular cytoplasm, containing 1 to several oleaginous-like globules; germinating by the formation of an extramatrical, aculeated sporangium lacking an apiculus; liberating zoospores.

Zoosporangia multispora, aggregata, globosa, inoperculata, myalinula, aculeata, 14.2–28.0  $\times$  16.8–32.3, circiter 23.4  $\mu$  in diametro  $\times$  28.2  $\mu$  in altitudine sine apiculo; cum exeunte poro in latere circiter 40° de apice; aculei angusti, hyalinuli, circiter 0.5–2.0  $\mu$  in longitudine, apicibus rotundis; apiculus cuculatus, hyalinulus, cum muris mollibus, 5.6  $\mu$  in diametro  $\times$  3.5–4.9, circiter 3.8  $\mu$  in altitudine. Zoosporae, sphaericae ad ovoideas, hyalinulae, 4.2–7.0  $\mu$  in diametro, cum magno claro globulo refracto; flagellum circiter 25  $\mu$  in longitudine; zoosporae vagina condensans distale, permanens apiculus spor-

angialus post germinationem. Pars intramatricalis thalli, crassa, ampla; cum 2 apophysibus muro zygosporiaco-hospitis separatis, rare cum 3 apophysibus, et cum amplo, ramoso rhizoid, ad  $3.6\ \mu$  in diametro, ex apophyse distale, minuente ad apices molles. Apophyses sphaericae, ovoideae aut fusiformes, cum plana hyalinula membrana; apophysis proxima  $5.6\text{--}7.0$ , circiter  $5.9\ \mu$  in diametro, distalis  $4.2\text{--}21.1$ , circiter  $11.2\ \mu$  in diametro. Quiescentia sporidia plana, sphaerica, ovoidea aut inaequalia,  $14.0\text{--}32.2$ , circiter  $22.2\ \mu$  in diametro, cum muro hyalinulo, duorum ordinum  $3.0\text{--}5.0$  in crassitudine; endosporidium  $2.0\text{--}3.8\ \mu$ , exosporidium circiter  $1.0\text{--}1.2\ \mu$  in crassitudine; cum cytoplasma tenuiter granulosa, habente unum ad varios globulos oleaginos; germinante formatione sporangii extramatricalis aculeatique sine apiculo; liberante zoosporas.

Parasitic and saprophytic in the zygospores of *Spirogyra majuscula*, *S. Weberi*, and probably others; several parts of Europe and Seymour, Wisconsin.

#### DEVELOPMENT OF THE THALLUS

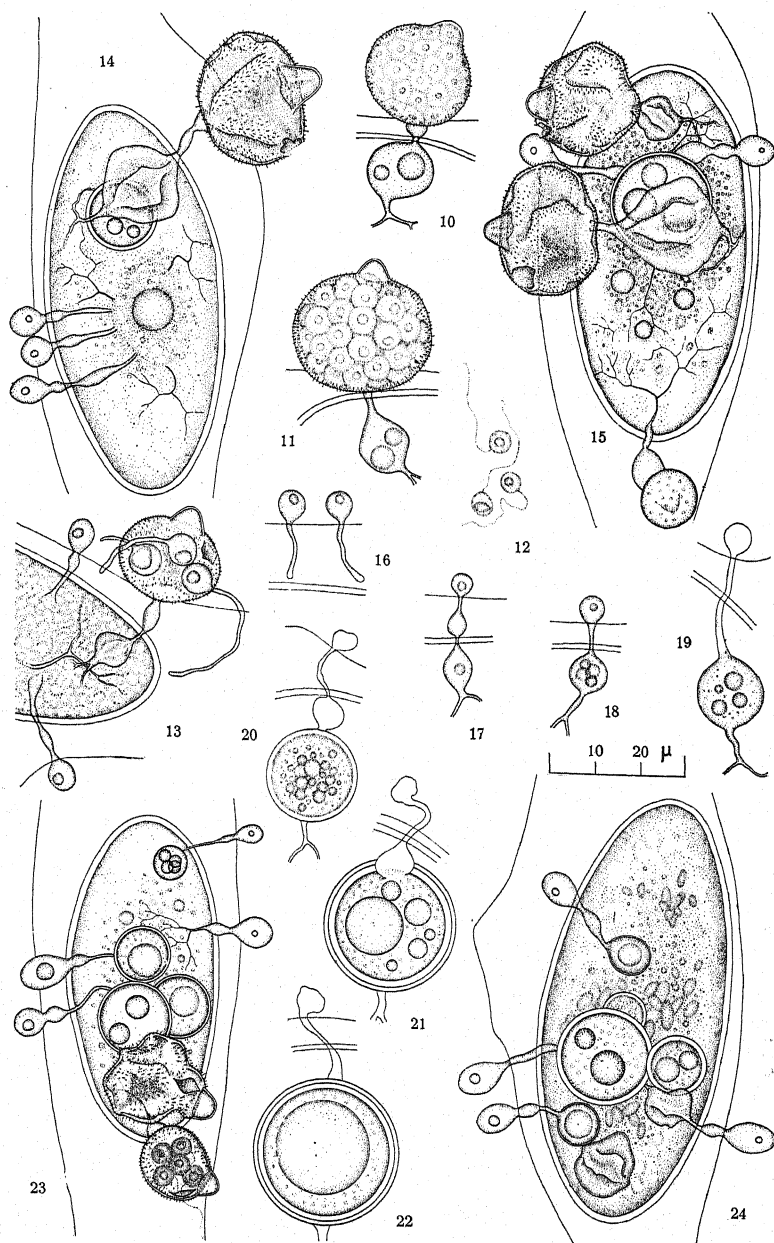
The zoöspores of *Blyttomyces spinulosus* are spherical when at rest or slightly ovoid when in motion, hyaline, slightly vacuolated,  $4.2\text{--}7.0\ \mu$  in diameter. Each contains a conspicuous, clear, spherical or irregular globule and a single posteriorly attached flagellum about  $25\ \mu$  long (FIG. 12). Occasionally the globule is in a central position but in most zoöspores it is located near the anterior part of the cell. Locomotion is more or less uniform, occasionally rotational and is accompanied by feeble amoeboid movements when solid surfaces are contacted.

The zoöspores finally come to rest and germinate by sending out a delicate germ tube. Contact with a particular type of substratum is not a requisite for germination since some spores germinate free in the water. If the germ tube comes in contact with a host cell it penetrates the wall, and the young thallus utilizes the reserve food of the host for its continued growth. If no suitable host is reached by the growing tip of the germ tube, the young thallus does not develop further but disintegrates. The majority of thalli develop from zoöspores which germinate on the surface of the host cell.

The tip of the germ tube is bluntly rounded or inflated and is filled with hyaline cytoplasm; the cytoplasm back from the tip is more dense and slightly granular. Early growth apparently results from the absorption of water by the spore since the only

visible changes in its contents are the enlargement of the vacuoles already present and an increase in their number. The diameter of the germ tube at this stage varies from  $1.5\text{--}3.0\ \mu$  with the greatest diameter at its tip (FIGS. 2, 3). The space between the host cell wall and the zygosporangium wall is rapidly traversed by growth of the germ tube until it comes into contact with the surface of the zygosporangium (FIG. 3). Contrary to the observations of Blytt (1882), no branching of the germ tube was seen before it penetrated the zygosporangium wall. A pore is next dissolved in the zygosporangium wall, and the tip of the germ tube grows into the interior of the zygosporangium and thus gains access to the reserve food of the host. It then grows into the protoplast and branches repeatedly.

A portion of the germ tube immediately inside the zygosporangium wall soon begins to enlarge as the anlage of an intramatrical subsporangial apophysis. An early stage in the formation of such a structure is shown in figure 4; here the enlarging portion is, as yet, hardly perceptible. Soon one or more refractive globules, similar to those of the zoöspores, appear in the cytoplasm of the enlarging apophysis (FIG. 5). When the size of the apophysis approaches that of the incipient extramatrical sporangium, the anlage of a secondary apophysis usually appears in the portion of the germ tube just outside the zygosporangium (FIGS. 5, 6). Its course of development, as a rule, is similar to that of the primary one, but usually it is smaller because of its delayed development (FIGS. 9, 10). However, exceptions to this relationship are not entirely lacking as shown in figures 8 and 15. In immature stages both show the same variations in shape; each begins as a vesicular, spindle-shaped swelling of the germ tube, and each becomes ovoid or spherical at maturity. Primary apophyses range from  $4.2\text{--}21.1\ \mu$  in diameter, averaging  $11.2\ \mu$ ; secondary ones from  $5.6\text{--}7.0\ \mu$  in diameter, averaging  $5.9\ \mu$ . It is of interest to note that the size of the secondary apophyses is more constant than that of the primary ones. Several mature thalli were observed in which either one or both of the apophyses was absent, and one immature thallus was found in which two secondary apophyses were developing at the same time (FIG. 7). When they reach maturity two or three large globules are often present (FIGS. 9-11).

FIGS. 10-24. *Blyttiumyces spinulosus*.



Formation of the primary apophysis, beginning as it does at some distance from the point of origin of the first rhizoidal branches, precludes the occurrence of polyrhizoidal thalli. No thalli were observed which had extraneous rhizoids extending from various points on the surface of the apophysis as in certain species of *Entophlyctis*. The conditions conducive to or necessary for the formation of polyrhizoidal thalli has been well shown by Karling (1931).

The diameter of the rhizoids varies from  $3.6\mu$  or more at the point of attachment to the apophysis to thinner delicate threads which taper to barely visible points at their extremities. Their contents, when visible, are irregularly granular and hyaline.

#### DEVELOPMENT OF THE ZOÖSPORANGIUM

Development of the zoösporangium is not delayed until the intramatrix parts of the thallus have reached their final size and absorptive capacity but begins at the time the zoöspore encysts on the surface of the host. Coincident with penetration by the germ tube, certain important and striking changes occur in the size, shape and detailed structure of the extramatrix spore body. Its distal hemisphere develops a thickened hyaline wall which gradually diminishes in thickness toward its equator (FIG. 2). This portion of the wall is the primordium of a future rigid, thick-walled, cucullate apiculus or ornamentation which will persist as such at the apex of the mature zoösporangium (FIGS. 11, 13-15, 23). Early development of this apiculus is fundamentally similar to the development of the apical spine in *Obelidium mucronatum* Nowakowski. Formation of the latter was described in detail by Sparrow (1938) who pointed out that the spine is set off early from the sporangium by the formation of a septum. In *Blyttomyces*, however, the contents of the apiculus are confluent with those of the sporangium. Formation of the apiculus does not correspond to the development of an operculum of the *Chytridium* type since it was shown by Karling (1936) that the operculum in *Chytridium lagenaria* Schenck begins to form only after the sporangium has approached its mature proportions. That appears to be the usual course of development in operculate forms. Measurement of apicula on mature sporangia indicates that very little if any equatorial growth

follows the original thickening of the spore wall. As a result, enlargement of the incipient sporangium is confined to its proximal region; and the sporangium assumes a pyriform rather than a spherical shape (FIGS. 5-8).

The contents of the developing sporangium are finely granular and vacuolated. No refractive globules are visible, but during the succeeding growth stages numerous small ones make their appearance and increase in size until they resemble those of the zoöspores (FIG. 9). Accompanying these changes, the sporangium has attained mature size by translocation of material from the intramatrical portion of the thallus. During the final stages of enlargement the greater part of the contents of the apophysis flow more or less rapidly into the sporangium so that the former may finally contain only a few scattered granules and oil globules separated from the contents of the sporangium by a septum.

Mature zoösporangia are almost spherical or globose with an equatorial diameter slightly greater than the polar diameter exclusive of the apiculus (FIG. 10). They range from  $14.2\text{--}28.0\ \mu$  in diameter  $\times 16.8\text{--}32.3\ \mu$  high, averaging  $23.4\ \mu$  in diameter  $\times 28.2\ \mu$  high. The apicula range from  $3.5\text{--}4.9\ \mu$  high, averaging  $3.8\ \mu$ , and the average diameter at the base, which is almost constant, is  $5.6\ \mu$ . As would be expected from its origin, the size of the apiculus is not proportional to the size of the sporangium upon which it is located but to the size of the zoöspore from which the thallus developed.

The contents of the sporangium are separated by cleavage furrows into a number of variable-sized portions, each of which encloses one of the refractive globules (FIG. 10). The cleavage portions are angular at first but soon become spherical and separated more or less from one another (FIG. 11). The refractive globule in each then appears quite prominent and similar to those of the free zoöspores (FIG. 12).

At the first indication of cleavage a striking change occurs in the nature of the sporangium wall which, until this time, has remained smooth over its entire surface. Numerous short hyaline projections appear on the surface of the sporangium exclusive of the apiculus, the latter remaining free of spines throughout the life of the thallus. The projections gradually elongate and become

more dense until they appear as opaque spines which give the sporangium an aculeated appearance at the time the zoöspores are mature (FIG. 11). They range from about  $0.5\text{--}2.0\mu$  in length and are of uniform diameter with their tips bluntly rounded rather than pointed.

Casual observation of immature zoösporangia might lead one to believe, as did Blytt (1882), that the apical ornamentation is an operculum which separates from the sporangium and thus forms an opening through which the contents pass to the outside. However, when the zoöspores are ready for liberation, an orifice appears in the lateral wall of the sporangium about  $40^\circ$  from its apex (FIGS. 13–15, 23), and the apiculus plays no part in spore discharge, but remains in place. In the several zoösporangia in which spore discharge was seen, the exit pore appeared to be formed by deliquescence of a localized area of the wall. The pore thus formed later became jagged and irregular as if it were torn during exit of the spores (FIGS. 14, 15). In any event, the zoöspores escape individually through this orifice after having reached maturity; in no case observed were the contents extruded into a thin-walled vesicle as described by Scherffel (1926). After passing into the water the zoöspores pause momentarily and then move quickly away.

In exceptional cases all the zoöspores may not escape through the sub-apical pore as described but may remain inside and germinate. The resulting germ tubes either project through the exit pore or penetrate through the sporangium wall. In one such case three spores sent their germ tubes through the wall of the sporangium, two penetrated the host cell wall, and one of them had almost contacted the surface of the original zygospore (FIG. 13). The refractive globule apparently is used as food during the early stages of development since the size of the globule in each of the germinating spores was inversely proportional to the length of its germ tube. Such spores were never observed to send their germ tube into the host cell through the old germ tube and apophysis of the original sporangium as in *Phlyctochytrium chaetiferum* Karling (Karling, 1937). Among other abnormal phenomena were several sporangia which had developed between the two walls of the host. When zoöspores were liberated from such sporangia, they

had no exit to the outside and consequently germinated free in the lumen of the cell or in contact with the surface of the zygospore.

#### DEVELOPMENT OF THE RESTING SPORE

Resting spores are formed in abundance during later stages of infection after most of the reserve food of the zygospore has been utilized by the fungal thalli. Although generally but 3 or 4 are formed in a single zygospore (FIGS. 23, 24), as many as 7 have been observed in the present material, Petersen (1910) figured 14, and Cejp (1932) has photographed as many as 12. This difference in the number of resting spores per zygospore may be related to the different host species involved in the different collections.

Only one resting spore is formed from a single thallus, and the process of formation involves enlargement, accumulation of reserve food and encystment of the primary apophysis (FIGS. 16-22). Early stages in development of thalli which will form resting spores are similar in certain respects to those of thalli which form zoösporangia. The most obvious difference is the failure of the zoöspore wall to thicken to the same degree as in the zoösporangial thalli (FIG. 16). Shortly after the first rhizoidal branches have been established, the anlage of a prominent primary apophysis appears and enlarges rapidly. Its size and shape are similar to those previously described, but here the apophysis soon becomes spherical (FIG. 18, 19). This type of growth is distinctly endogenous and is similar to that of *Chytridium*. Oleaginous-like globules appear, and their substance will persist in the mature resting spore where it probably will serve as reserve food during germination. The contents of the germ tube and rhizoidal system apparently become incorporated into the resting spore because they soon appear empty and somewhat collapsed. The presence of a hyaline periphery on the apophysis at a slightly later stage (FIG. 20) indicates that a thickened wall is being laid down about the developing spore. This soon destroys communication with the rhizoidal system at one pole and with the germ tube at the other. An increase in the size of the globules, accompanied by a decrease in their number, indicates that they probably begin to

coalesce at this time. As the resting spore approaches maturity, the wall becomes differentiated into two layers, and no further size increase occurs. The inner layer, or endospore, of the wall is usually thicker and more hyaline than the exospore. In all the material we have examined there were no rugose resting spores as described by Cejp (1932). Secondary apophyses occur only occasionally in these thalli, and rarely two apophyses may form inside the zygosporangium (FIGS. 20, 21). Further coalescence of the refractive globules may or may not occur so that some mature spores contain a single large globule that fills almost the entire cell (FIG. 22) while others contain a number of them suspended in the protoplasm (FIG. 21).

Mature resting spores are usually smooth-walled spherical, ovoid or sometimes irregular depending upon their number, size and location in the zygosporangium. They range from 14.0–32.2  $\mu$  in diameter, averaging 22.2  $\mu$ . The wall ranges from 3.0–5.0  $\mu$  in thickness, the endospore from about 2.0–3.8  $\mu$  and the exospore from about 1.0–1.2  $\mu$ . If a single refractive globule is present, it is usually eccentric in position (FIG. 22).

Only a few resting spores were observed to germinate but our observations agree with those of Petersen (1910), Blytt (1882), Denis (1926) and Cejp (1932). The final result of resting spore germination is the formation of an extramatrical sporangium which liberates zoospores. Blytt (1882) and Cejp (1932) described the resting spore as sending a germ tube to the surface of the host where its tip enlarges to form a sporangium. It was impossible in the present material to determine whether the contents of the resting spore pass out into the old zoospore case as in the germination of resting spores of *Chytridium lagenaria* (Karling, 1936) or whether new germ tubes are sent out to the surface of the host as reported by Blytt (1882) and Cejp (1932). It is possible that both methods occur under appropriate conditions. Several stages in resting spore germination are shown in figures 23 and 24. Discharge of zoospores from resting sporangia was not observed, but the characteristics of a single empty one are the same as those described by Blytt (1882). He found that the sporangium is small and spiny-walled and lacks an apiculus. Absence of the apiculus is not surprising in view of the fact that the

wall of the old spore undergoes no unequal thickening and because resting sporangia may possibly form by enlargement of the tips of new germ tubes. The exit pore on this sporangium also was located about 40° from the apex and in this character was similar to the zoösporangia.

Blytt (1882) reported that in some cases the resting spores are formed by a process of copulation since he observed only one half as many resting spores as the number of thalli which had formed. In addition he saw what he considered to be empty haustoria which had fused with others. In the present material no such copulation was seen, nor did there appear to be any type of sexual process involved in the formation of resting spores. His observation that the number of resting spores does not correspond with the number of thalli is not significant since zoösporangial thalli do not form resting spores and are actually empty in later stages. It is also possible that Blytt was dealing with several different fungi in the same host.

#### DISCUSSION

That this fungus is capable of parasitic growth is shown by its infection of *Spirogyra* zygospores which apparently are living and in a normal healthy condition. It is also capable of saprophytic nutrition since numerous infections occur on zygospores which have been depleted of food by other thalli (FIG. 14). The lethal effect upon the host is almost immediate following establishment of the rhizoidal system, and this is manifested by the breakdown of the chloroplasts and the appearance of oil globules. Later on, the only remains of the zygospore contents are a few scattered granules which appear to be broken down pyrenoids (FIG. 24) or several oil globules of different sizes mingled with numerous smaller granules (FIGS. 15, 23). The enzymatic activity of the rhizoidal system seems to have little if any effect upon the zygospore wall. In this respect it is strikingly different from the thallus of *Lagenidium americanum* Atkinson, also an inhabitant of *Spirogyra* zygospores, which uses up or at least destroys the wall completely.

The host range of *Blyttomyces spinulosus* is apparently quite restricted and has been reported only from species of *Spirogyra*.

The species of *Spirogyra* were not determined for the collections of Blytt (1882) from Norway, of Petersen (1910) from Denmark, of Scherffel (1926) from Slovakia, nor Cejp (1932) from Slovakia. Denis (1926) believed the host he collected from France to be *S. majuscula* Kützing. The reports of this fungus only from species of *Spirogyra* indicates that it probably is restricted to this genus.

In considering the relationship of *Blyttiomycetes* to other genera of the Rhizidiaceae it becomes apparent at once that its affinities point to the genus *Chytridium*. The occurrence of an operculum-like structure on the apex of the zoösporangium might lead one to conclude that the former is virtually the relic of a pre-existing operculum which has lost its function after the establishment of an exit pore method of zoöspore discharge. That this is unlikely is shown by a comparison of its formation with that of a typical operculum as found in *Chytridium* (Karling, 1936), in *Endochytrium* (Sparrow, 1933; Karling, 1938), and *Nowakowskiella* (Sparrow, 1933). In these genera the operculum does not form until the zoösporangium has attained almost its mature proportions, and it has no anlage which develops from a distinct part of the zoöspore. The general habit of growth, the formation of intramatrical resting spores, and the method by which they germinate shows clearly a close relationship between this fungus and *Chytridium*.

#### ACKNOWLEDGMENTS

This investigation was carried out under the direction of Dr. E. M. Gilbert during the tenure of an Alumni Research Assistantship by the writer. Many helpful suggestions and pertinent information were also given by Dr. F. K. Sparrow, Jr., of the University of Michigan, and the Latin diagnoses were written by Mrs. N. E. Stevens of Champaign, Illinois. The writer wishes to express his appreciation of their willing assistance.

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## EXPLANATION OF FIGURES

All figures were drawn with the aid of an Abbe camera lucida, using a 10 × ocular and 1.8 mm. objective; original magnification of figures is 1600 ×.

Fig. 1. Zoöspore resting on surface of host; 2, elongation of germ tube in direction of host zygospore; 3, germ tube in contact with zygospore wall; 4, early stage in formation of rhizoidal system (note incipient sporangium beginning to enlarge and take on pyriform shape); 5-6, early development of primary and secondary apophyses containing refractive globule; 7, abnormal specimen forming 2 secondary apophyses; 8-11, enlargement of zoösporangium and formation of zoöspores; 12, zoöspores after liberation from sporangium; 13, sporangium with 3 germinating zoöspores (note that 2 germ tubes have penetrated host cell wall and are growing toward original host zygospore); 14-15, zygospores of *Spirogyra* with young thalli, empty zoösporangia showing location of exit pore, and 2 resting spores; 16-21, stages in development of resting spore; 22, resting spore with single large globule; 23-24, *Spirogyra* zygospores with young thallus, resting spores, germinating resting spores, and one sporangium liberating zoöspores.



# STUDIES ON THE USTILAGINALES OF THE WORLD <sup>1</sup>

GEORGE L. ZUNDEL

(WITH 3 FIGURES)

The purpose of this paper is to record the results of studies on specimens of Ustilaginales received from various countries of the world. One new genus and fifteen new species are recorded.

## I. NOTES ON SMUTS REPORTED ON *CYNODON DACTYLON* (L.) PERS.

In 1847 Tulasne <sup>2</sup> reported *Cynodon Dactylon* as a host plant for *Ustilago Carbo*. Later in 1870 Passerini <sup>3</sup> described and issued this smut in exsiccati as *Ustilago Carbo* Tul.  $\beta$  *Cynodontis* Pass. P. Hennings <sup>4</sup> in 1891, based on a collection by G. Schweinfurth in Erythrea, used the name *Ustilago segetum* (Bull.) Dittm. var. *Cynodontis* P. Henn. In present day literature this smut is now usually referred to as *Ustilago Cynodontis* P. Henn. However, in 1927 Curzi <sup>5</sup> correctly suggested that the name should be written *Ustilago Cynodontis* (Pass.) Czi. The name *Ustilago Cynodontis* P. Henn. <sup>6</sup> was not published till 1893.

Another smut was described by Tulasne <sup>7</sup> in 1847 based on a collection at the Cape of Good Hope and deposited in the Drege Herbarium (no. 9467) as *Ustilago Dregeana* Tul. but no host was given. Notwithstanding the excellent article by P. Magnus <sup>8</sup> in which all of the species of smuts on *Cynodon Dactylon* are carefully differentiated, these species have been confused in later

<sup>1</sup> The Latin diagnoses of new species were written by Dr. R. E. Dengler of the Pennsylvania State College, to whom the author expresses his appreciation and thanks.

<sup>2</sup> Ann. Sci. Nat. III. 7: 82. 1847.

<sup>3</sup> Erb. Critt. Ital. II. no. 450. 1870.

<sup>4</sup> Bot. Jahrb. (Engler) 14: 369. 1891.

<sup>5</sup> Atti Ist Bot. Univ. Pavia III. 3: 153. 1927.

<sup>6</sup> Bull. Herb. Boiss. 1: 144. 1893.

<sup>7</sup> l.c. p. 83.

<sup>8</sup> Les Ustilaginees du *Cynodon Dactylon* (L.) et leur distribution géographique. Bull. Soc. Myc. Fr. 15: 265-271. 1899. *ill.*

literature. Even as late as 1927, Verwoerd<sup>9</sup> considered *Ustilago Cynodontis* P. Henn. as a synonym of *Ustilago Dregeana* Tul. The confusion apparently began in 1882 when von Thumen reported<sup>10</sup> *Ustilago Dregeana* Tul. on *Cynodon Dactylon*, based on a collection by MacOwan in East Africa. Later in Saccardo's *Sylloge Fungorum*<sup>11</sup> the habitat of *U. Dregeana* is reported as "inflorescence graminis in *C. Bonae Spei* (Drege) & *Cynodontis Dactyli*, Somerset East Africa (MacOwan)."

In order to further emphasize the difference between these species, the writer has been able to secure parts of original collections and reexamine them.

Collections of *Ustilago Cynodontis* P. Henn. from Australia, Siberia, Texas and Tunis were examined under high power. In all cases the spores were chiefly globose, olivaceous brown and smooth, averaging 7  $\mu$  in diameter (FIG. 1A).

Through the courtesy of the Director of the Royal Botanical Garden, Kew, England, some spores of the MacOwan collection, marked *Ustilago Dregeana*, were secured. An examination showed that they agreed perfectly with those of *Ustilago Cynodontis* P. Henn. (now *Ustilago Cynodontis* (Pass.) Czi.).

A portion of the type of *Ustilago Dregeana* Tul. was secured from the Laboratoire de Cryptogamie of the Museum National d'Histoire Naturelle in Paris through the courtesy of Dr. Roger Heim. An examination of this material showed that the spores were reddish-brown, with a dark thick epispore and under high magnification were papillate to warty, 4-5  $\mu$  diam (FIG. 1B). From the illustrations of the spores of *U. Cynodontis* and *U. Dregeana* one wonders how the two species were ever confused.

It must be noted that in the original Tulasne description of *Ustilago Dregeana* no host was given. It merely says "Gramen morbosum in Herbario Dregeana (no. 9467)" etc. In an attempt to find the name of the host, a portion of the type specimen of *U. Dregeana* was sent to Mrs. Agnes Chase of the U. S. Dept. of Agriculture for her opinion. Under date of May 27, 1937, she reports in part as follows: "This host is certainly not a species of

<sup>9</sup> Ann. Univ. Stellenbosch A. 4: 19. 1926.

<sup>10</sup> Grevillea 9: 18. 1882-1883.

<sup>11</sup> Sacc. Syll. Fung. 7: 467. 1888.

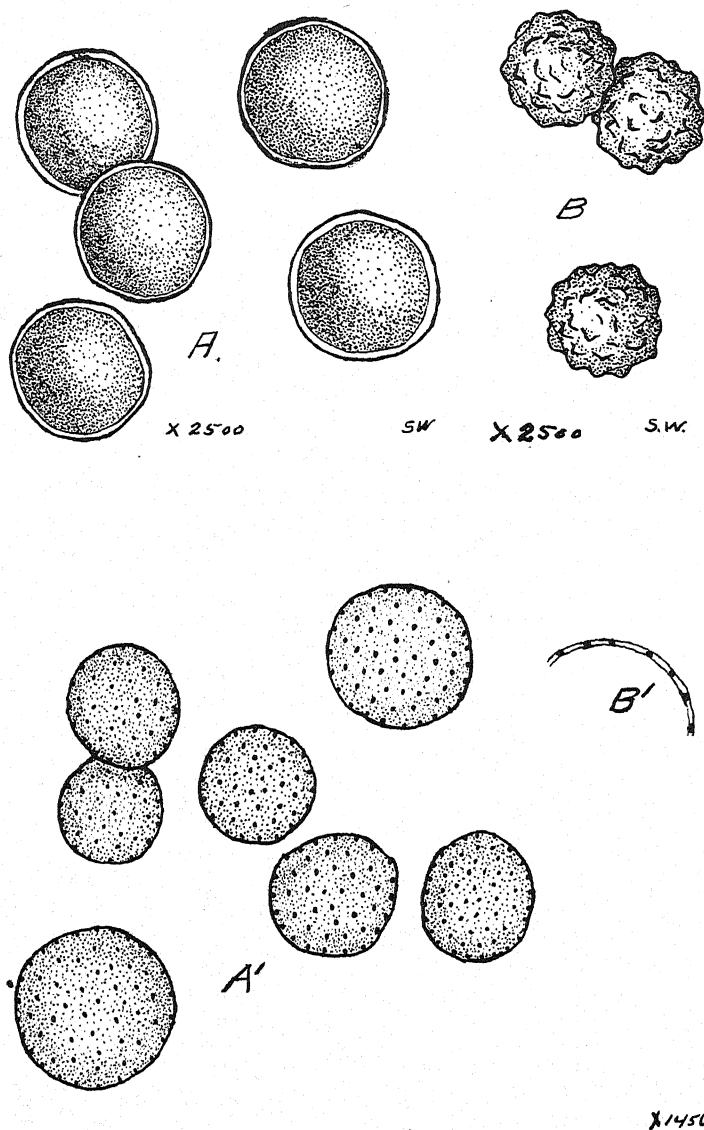


FIG. 1. A, spores of *Ustilago Cynodontis* P. Henn.; B, spores of *Ustilago Dregeana* Tul. (type); A', spores of *Ustilago paraguariensis* Speg.; B', section of epispore.

*Cynodon*. I feel confident that it is a species of *Eragrostis*. I have been through all the African material to compare with your specimen. There is practically nothing to go by except the hairs at the summit of the sheath. There are some ten or twelve species of Africa that have hairs much like this. Of these, three are common in the region of the Cape, where Drege collected, and of these three, *Eragrostis porosa* Nees, I think, matches your specimen fairly well." This then seems to be proof that the two species of smuts do not even occur on the same host plant.

Another species on *Cynodon Dactylon* was described by Spegazzini from Paraguay, which he named *Ustilago paraguariensis*.<sup>12</sup> This species is said to differ from *U. Cynodontis* P. Henn. by the larger spores which are granular to echinulate. In the article by P. Magnus,<sup>8</sup> already referred to, the spores of these two species are pictured and the distinctions noted. Curzi,<sup>5</sup> in the above mentioned article, considers *U. paraguariensis* Speg. a synonym of *U. Cynodontis*. Original exsiccati specimens of *U. paraguariensis* Speg. have been examined and found to not agree in spore markings with *U. Cynodontis*, but do agree in size of spores, averaging 10.5  $\mu$  in diam.

Spores of *U. paraguariensis* Speg. from Roumeguere Fungi Sel. Exs. no 4113, collected at Balansa, the type locality, from the Farlow Herbarium were examined, and under oil immersion the spores are olivaceous brown with thickened or punctate areas in the epispore which at first suggest echinulations (FIG. 2A), and average 10.5 in diam. The thickenings in the wall are shown in figure 2B.

Spores of *U. paraguariensis* from a second collection from the exsiccati collection of the Connecticut Agricultural Experiment Station (no. 1322, Vest. Micr. Rar. Sel) were examined under oil immersion, and were found to be olivaceous brown, indistinctly granular, averaging 10.5  $\mu$  diam. There seems to be no question but that *U. Cynodontis* P. Henn. and *U. paraguariensis* Speg. are distinct species. In *U. paraguariensis* Speg. the granular thickenings are visible only under oil immersion. The spores appear smooth when examined under low magnification.

<sup>12</sup> Anal. Soc. Ci. Argent. 17: 89. 1884.

## II. A NEW GENUS OF THE USTILAGINALES FROM SOUTH AFRICA

**Xylosorium** Zundel, gen. nov.

Sori as oval pustules on the stem, 3–4 septate, covered with a hard spongy coriaceous membranè which ruptures irregularly at maturity disclosing a dark brown semi-agglutinated spore mass; spore-balls composed of many fertile spores which usually disintegrates into single spores at maturity.

Germination not known.

Type species, *Xylosorium Piperii* Zundel.

Soris in stirpe pustulis ovalibus, 3–4 septatis, membrana dura spongiosa coriaceaue tectis, membrana matura irregulariter rupta massam atro-brunneam et semi-agglutinatam sporarum detegit; globulis sporarum ex-multis et fertilibus sporis compositis in singulasque sporas mature disin-tegratis. Germinatio non cognoscitur.

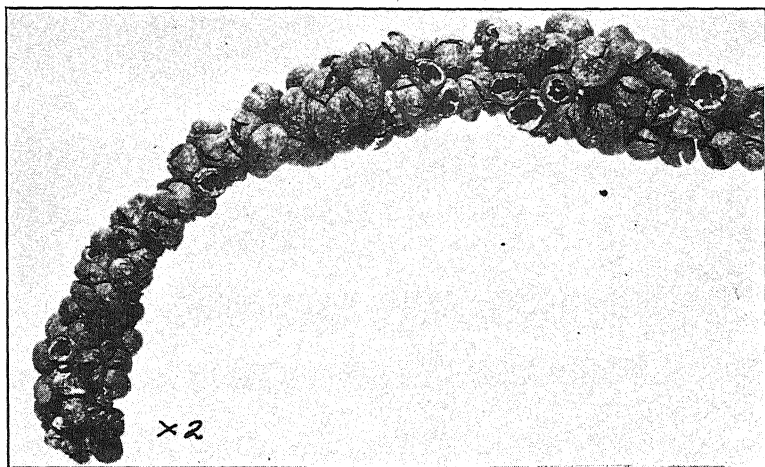
**Xylosorium Piperii** Zundel, sp. nov.

Sori as hard coriaceous, oval pustules on the stem, 1.5 to 2 mm. in diam., 3 to 4 septate, at maturity rupturing irregularly on the upper side of the sorus, spore mass dark brown, semi-agglutinated but later becoming powdery; spore-balls many spored, broadly ellipsoidal, opaque, dark colored, semi-permanent, chiefly 77 to 115  $\mu$  long; spores globose to ellipsoidal, often angled by compression, light olivaceous-brown, smooth, somewhat zonate under high magnification, 7–10.5  $\mu$  long.

Soris duris coriaceis, ovalibus pustulis in stirpe, 1.5–2 mm. diam., 3–4 septatis, maturis irregulariter supra in soris ruptis, massa sporarum atro-brunnea, primo semi-agglutinata postea pulverulenta; globis multas sporas habentibus, late ellipsoideis, opacis, fuscis, semi-permanentibus, plerumque 77–115  $\mu$  longis; sporis globosis vel ellipsoideis, saepe per compressionem angulatis, sub-olivaceo-brunneis, levibus, aliquantum zonatis "sub oleo," 7–10.5  $\mu$  longis.

On *Piper* sp., Transvaal, Union of South Africa, collected by Archdeacon Rogers, Nov. 1915 (Union Dept. Agr. Myc. Herb. No. 11806) (FIG. 2).

This peculiar smut is one of the few species ever reported on woody plants. It was with difficulty that the writer convinced himself that it was a member of the Ustilaginales. The spores are apparently too old to germinate but the genus is temporarily included in the Ustilaginaceae until fresh material is collected and the spores germinated (FIG. 2).

FIG. 2. *Xylosorium Piperii* Zundel.

## III. SMUTS COLLECTED IN COLUMBIA BY C. E. CHARDON

The following smuts were sent to the writer by Dr. H. H. Whetzel of Cornell University and have been determined as follows:

*Cintractia caricis* (Pers.) Magn. on *Carex Boudplanii* Kunth., Teguendama, Dec. 13, 1938 (no. 872), and Penanegra above Facatotiva, March 28, 1937 (no. 864); *Carex chordalis* Liebm., Teguendama, Dec. 13, 1936 (no. 870); *Farysia olivacea* (DC.) Sydow, on *Carex Haenkeana* Presl, swampy ditches near Facatotiva, March 28, 1937 (no. 863); *Sphacelotheca borealis* (Clint.) Schell, on *Polygonum punctatum* Ellis, La Virginia, Camine del Buiz, Dec. 25, 1936 (no. 865); *Urocystis anemones* (Pers.) Wint. on *Ranunculus* sp., La Laguna, Paramos del Buiz, Dec. 27, 1936 (no. 871); *Ustilago Hordei* (Pers.) Kellerm & Swingle, on *Hordeum vulgare* L., outskirts of Bogota, March 7, 1937.

## IV. SMUTS COLLECTED IN MINAS GERAES, BRAZIL BY A. S. MÜLLER

The following smuts were sent to the writer by Dr. H. H. Whetzel of Cornell University for determination.

*Entyloma Oryzae* Sydow, on *Oryza sativa* L. var. Honduras, Viçosa, Escola, March 20, 1930 (no. 1011).

- Mykosyrinx Cissi* (DC.) Beck, on *Cissus sicyoides* L., Viçosa, May 27, 1930 (no. 177).
- Sorosporium reilianum* (Kuhn) McAlpine, on *Zea Mays* L., Viçosa, Escola, May 16, 1933 (no. 534).
- Sphacelotheca cruenta* (Kuhn) Potter, on *Sorghum vulgare* Pers. (*Holcus sorghum* L.) (sorgo), Vicoso-Escola, May 19, 1932 (no. 344).
- Sphacelotheca culmiperda* (Schroet.) Clint., on *Andropogon bicornis* L., Vicoso, Feb. 25, 1934 (no. 739).
- Sphacelotheca bicornis* (P. Henn.) Zundel, on *Andropogon bicornis* L., Uberlandia, May 19, 1936 (no. 1082), also Vicoso-Escola, March 20, 1932 (no. 322).
- Tilletia rugispora* Ellis, on *Paspalum plicatum* Michx., Curvello, Feb. 1, 1936 (no. 1010).
- Tolyposporium Cenchrì* Bref., on *Cenchrus echinatus* L., Rio Branco, July 31, 1934 (no. 828).
- Ustilago Avenae* (Pers.) Jens. on *Avena sativa*, Vicoso-Escola, Feb. 20, 1930 (no. 619).
- Ustilago gregaria* Zundel, on *Panicum rivulare* Trin., Barrosa, Feb. 18, 1934 (no. 710).
- Ustilago Schroeteriana* P. Henn., on *Panicum Urvillei* Steud., Vicoso-Escola, Dec. 1, 1929 (no. 69).
- Ustilago Tritici* (Pers.) Rostr. on *Triticum vulgare* L., Vicoso-Escola, Feb. 3, 1930 (no. 99); also Dec. 7, 1933 (no. 646).
- Ustilago Zeae* (Beck.) Ung., on *Zea Mays*, Vicoso-Escola, March 12, 1931 (no. 316); on *Euchlaena mexicana* Schrad, Escola-Vicoso, March 20, 1932 (no. 318).

V. SOUTH AMERICAN SMUTS FROM THE FARLOW HERBARIUM,  
HARVARD UNIVERSITY

- Cintractia leucoderma* (Berk.) P. Henn., on *Rhynchospora aurea*, Pl. Vryheid, British Guiana, coll. D. H. Linder (no. 942), Feb. 14, 1924.
- Cintractia utriculicola* (P. Henn.) Clinton, on *Rhynchospora corymbosa* (L.) Brit., Pl. Vryheid, British Guiana, coll. D. H. Linder (no. 941), Feb. 14, 1924.
- Entyloma australe* Speg., on *Physalis* sp., Buenos Aires, Argentina, coll. Roland Thaxter (acc. no. 7893), 1905-'06.

*Ustilago bromivora* (Tul.) Fisch. de Wald., on *Bromus catharticus* Vahl., El Prado, Motevideo, Uruguay, coll. R. Thaxter, Oct. 22, 1905 (acc. no. 7896), also near St. Catharina, Agricultural School, Argentina, March 25, 1906, coll. R. Thaxter (acc. no. 7900).

*Ustilago minima* Arth. on *Stipa hyalina* Nees, Montevideo, Uruguay, coll. R. Thaxter, Oct. 22, 1905 (acc. no. 7894).

*Ustilago Rabenhorstiana* Kuhn, on *Digitaria* sp.? Buenos Aires, Argentina, coll. R. Thaxter, Oct. 1905 (acc. no. 7897).

***Ustilago Thaxteri* Zundel, sp. nov.**

Sori destroying the inflorescence, extending down and surrounding the upper portions of the stems, at first partially hidden by the sheaths, 10 cm. or more in length, at first covered by a whitish delicate membrane of host tissue which flakes away revealing a semi-agglutinated spore mass, later becoming dusty, surrounding the inflorescence and stems; spores light olivaceous-brown, chiefly subspheric, somewhat irregular, smooth, often guttulate, chiefly 8–12  $\mu$  in length.

Soris inflorescentiam destruentibus, descendentibus et superior caulium cinogentibus, primo partim in vaginia celatis, 10 cm. vel amplius longis, subalba et delicata membrana primo tegatis; membrana postea in laminae rupta semi-agglutinata sporarum massam detegit; membra postea pulverulenta facta caulis circumstat; sporis sub-oliveo-brunneis, plerumque subsphericis, irregularibus, levibus, saepe guttulatis, plerumque 8–12  $\mu$  longis.

On *Leptochloa uninervia* (Presl.) Hitch. & Chase, Buenos Aires, Argentina, coll. Roland Thaxter, Sept. 29, 1905 (Farlow Herb. acc. no. 7899, type); Sept. 29, 1905 (Farlow Herb. acc. no. 7909); Oct. 8, 1905 (Farlow Herb. acc. no. 7911).

VI. NOTES ON *USTILAGO CARBO*  $\gamma$  *COLUMELLIFERA* TUL

In 1847, Tulasne<sup>13</sup> published the name *Ustilago Carbo*  $\gamma$  *columellifera* and described two varieties as follows:

$\gamma$  *columellifera*: gleba ustilaginea definita, ovarii locum tenens, columellam simplicem vel ramoso-spinescentem includens, bracteis propioribus liberis vel ipsi partim adnatis; sporis diametro 0 $\mu$ mm, 0096–0128 crassis, saturiatis coloratis.

a. *transfissa*.—Mole ustilaginea ovarum mentiente, centrali et plane libera; columella simplici. (In *Andropogo hirta*.)

b. *trichophora*.—Mole ustilaginea bracteis hinc pro parte adnata, columella ramoso-spinescente. (In *Panico Colonum*, *Penniseto cenchroide*.)

<sup>13</sup> Ann. Sci. Nat. III. 7: 81. 1847.



In using the name *Ustilago Carbo*, Tulasne was merely correcting nomenclature since DeCandolle had used the name *Ustilago Carbo*<sup>14</sup> in 1815 to include many of the cereal smuts, however, *Ustilago Carbo* Tul. included more than the cereal smuts.

In his two most extensive publications Fischer de Waldheim<sup>15, 16</sup> simply uses the name *Ustilago Carbo* Tul. with spores 6–8 micr. and lists from eleven to eighteen unrelated hosts for this smut, including the cereals and several grasses such as *Andropogon hirtus* L., *Cynodon Dactylon* Pers. but not *Pennisetum* sp. or *Panicum* sp.

In his second paper Fischer de Waldheim<sup>17</sup> recognizes the name *Ustilago Penniseti* Rabh. with spores 10–12.4 micr. and uses as a synonym *Ustilago Carbo* var. *columellifera*  $\beta$  *trichophora* Tul.

As to the other variety of *Ustilago Carbo*, the writer has found it only once since the original publication. Oudemans<sup>18</sup> lists *Ustilago segetum* (Bull.) Ditm. on *Andropogon hirtus* L. and gives as a synonym *Ustilago Carbo*  $\gamma$  *columellifera* a. *transfissa*.

Other writers have considered these smuts differently. In 1910, McAlpine<sup>19</sup> obtained a smut specimen labeled "*Ustilago Carbo* var. *columellifera* Tul." which he studied and concluded that it was a *Cintractia* and published the name *Cintractia columellifera* (Tul.) McAlp. with spores 7–8  $\mu$  diameter.

In 1928, Ciferri<sup>20</sup> published the name *Sphacelotheca columellifera* (Tul.) Ciferri but did not give a description so that one does not know the source of his material nor why the change in nomenclature was made. In 1930, the writer<sup>21</sup> published a description, presumably of the Tulasne species, using the name proposed by Ciferri. As material an Australian specimen was used which had been sent from the New South Wales Department, Biological Branch, No. 8A, and labeled "*Cintractia columellifera* on *Andropogon intermedius*, Coll. 1912. N. S.W." No collector or locality is given. This specimen had a sorus 5–7 cm. long and spores 7–12  $\mu$  diameter.

<sup>14</sup> Flore Francaise 6: 76. 1815.

<sup>15</sup> Apercu Systematique des Ustilaginales 12. 1877.

<sup>16</sup> Ann. Sci. Nat. VI. 4: 200. 1876.

<sup>17</sup> Ann. Sci. Nat. VI. 4: 210. 1876.

<sup>18</sup> Oudemans, C. A. J. A. Enum. Syst. Fung. 1: 704. 1919.

<sup>19</sup> Smuts of Australia 166. 1910.

<sup>20</sup> Ann. Myc. 26: 32. 1928.

<sup>21</sup> Mycologia 22: 139. 1930.

Yen,<sup>22</sup> in 1937, described and illustrated a smut on *Andropogon Lanigeri*, collected in Morocco, giving it the name of *Sphacelotheca columellifera* (Tul.) Yen, with spores 7.2–9.6  $\mu$  diameter.

From this brief review it is evident that there is confusion as to the identity of the Tulasne species referred to at the beginning of this paper. This is not surprising since the early writers listed so many unrelated hosts for *Ustilago Carbo*, its subspecies and varieties. The confusion cannot be wholly cleared up until many of the Tulasne specimens have been examined and named according to present day nomenclature.

Through the kindness of Dr. Roger Heim of the Museum National d'Histoire Naturelle, Laboratoire de Cryptogamie, Paris, France, two of the Tulasne specimens were loaned for examination. They are labeled as follows:

1. *Ustilago Carbo*  $\gamma$  *columellifera* a. *transfissa* Tul., on *Andropogon hirta*, LaCalle, Mai 1841.

2. *Ustilago Carbo*  $\gamma$  *columellifera* b. *trichophora* Tul., on *Cynodonte Dactylon*, LaCalle, 13 July 1840.

The following descriptions are a result of a careful microscopic examination of these specimens.

1. USTILAGO CARBO  $\gamma$  COLUMELLIFERA a. TRANSFISSA Tul. Ann. Sci. Nat. III. 7: 81. 1847.

Sori in the ovaries, 2–3 mm. long, concealed by the glumes, inconspicuous, ovoid, covered by a grey false membrane which flakes away revealing a dark agglutinated spore mass surrounding a columella; sterile cells hyaline, globose to subglobose, often irregular, usually in chains, variable in size, chiefly 7–10.5  $\mu$  diam.; spores globose to subglobose, sometimes irregular, dark-olivaceous to brown, subopaque, abundantly punctate, chiefly 10.5 to 14  $\mu$  diam.

On *Andropogon hirta*, LaCalle, Algeria, May 1841. Cryptogamie Ex. herb. Durieu de Maisonneuve. Legit L. Motelay (1878). Deposited in the Tulasne Herbarium, Museum National d'Histoire Naturelle, Laboratoire de Cryptogamie, Paris.

From the description we see that it is a *Sphacelotheca*, but that the spores are larger than those given by previous writers. The size of the spores do agree very closely to those given by Tulasne

<sup>22</sup> Rev. Myc. n.s. 2: 76–78. 1937.

for *Ustilago Carbo γ columellifera*, viz. 9.6–12.8  $\mu$  diam. The writer, therefore, proposes the name *Sphacelotheca transfissa* (Tul.) Zundel, nom. nov. for this species (FIG. 3A).

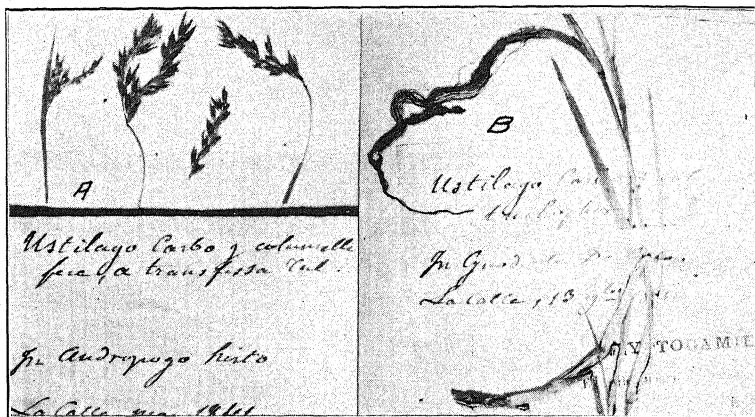


FIG. 3. A, *Ustilago Carbo γ columellifera*; a. *transfissa* Tul.; B, *Ustilago Carbo γ columellifera*; b. *trichophora* Tul.

2. *USTILAGO CARBO γ COLUMELLIFERA* b. *TRICHOPHORA* Tul. Ann. Sci. Nat. III. 7: 81. 1847.

Sori in the ovaries and inflorescence, 5–7 cm. long, cylindrical, covered with a grey membrane which flakes away revealing a granular, dark powdery spore mass intermixed with long shreds of host tissue; spore-balls dark, opaque, permanent, variously shaped, spheroidal to ellipsoidal, irregular, many spored 45–80  $\mu$  long; spores globose to subglobose, occasionally angled due to mutual pressure, light olivaceous brown, smooth, chiefly 3.5–6  $\mu$  diam., occasionally up to 7  $\mu$ .

On *Paspalum distichum*, La Calla, Algeria, July 13, 1840. Cryptogamie Ex. herb. Durieu de Maisonneuve. L. Motelay (1878). Deposited in the Tulasne Herbarium, Museum National d'Histoire Naturelle, Laboratoire de Cryptogamie, Paris.

In order to be sure of the identity of this host, the specimen was sent to Mrs. Agnes Chase, of the U. S. Department of Agriculture, who reports that the host is not *Cynodon Dactylon* L. as labeled, but probably *Paspalum distichum* L.

The writer has not found a *Sorosporium* on *Paspalum* sp. that agrees with the one in question and therefore considers it undescribed.

An examination of this specimen was surprising in three ways: (1) The host is given as *Cynodon Dactylon* while in the original description Tulasne gives *Panicum Colonum* and *Pennisetum cenchroides* as the hosts, but later names other hosts including *Cynodon Dactylon*. (2) This smut is a *Sorosporium*. (3) The spores are smaller than those given by Tulasne for *Ustilago Carbo*  $\gamma$  *columellifera*. Apparently then this is an unnamed species and on that assumption the writer proposes the name ***Sorosporium trichophorum*** (Tul.) Zundel, nom. nov. (FIG. 3B).

It is now evident that the Australian specimen used by the writer in 1930 was mislabeled "*Cintractia columellifera*." It is an unnamed *Sphacelotheca* and the writer proposes the following:

***Sphacelotheca MacAlpineae*** Zundel, sp. nov.

Sori destroying the inflorescence, long linear, 5-7 cm. long, at first concealed by the sheath but later protruding, covered by an evident yellowish white membrane which ruptures irregularly revealing a dark brown, agglutinated, spore mass surrounding a large well developed columella, false membrane breaking up into groups or chains of globose, hyaline, sterile cells, 7-12  $\mu$  diam.; spores chiefly globose, regular, light reddish brown, vacuolated under oil immersion, smooth, chiefly 7  $\mu$  diam., occasionally up to 9  $\mu$ .

Soris inflorescentiam destruentibus, longis linearibus, 5-7 cm. longis, primo in vagina celatis, postea protrudentibus, membrana lutescente tectis, quae irregulariter rupta massam atro-brunneam agglutinatam sporarum detegit magnam et maturam columellam circumcludentem, membrana falsa in glomerulas vel catenas cellarum globosarum, hyalinarum, sterilium rupente, 7-12  $\mu$  diam.; sporis plerumque globosis, regularibus, sub-rubro-brunneis, in "oleo" vacuolatis, levibus, plerumque 7  $\mu$  diam., raro usque ad 9  $\mu$ .

On *Andropogon intermedius* R. Br., New South Wales, Australia, Coll. 1912 (N. S. W. Dept. Agr., Biological Branch No. 8A, labeled *Cintractia columellifera*).

An examination of a specimen of *Ustilago columellifera* (Tul.) Yen and comparing it with the Tulasne specimen *Ustilago Carbo*  $\gamma$  *columellifera* a. *transfissa* shows that the two smuts are different. (1) The Yen specimen has smaller spores than the Tulasne specimen. (2) The Yen specimen has a larger sorus than the Tulasne

specimen. It, therefore, appears to be necessary to rename the Yen smut, and the writer proposes the following name, the description being practically identical to the original published by Yen:

**Sphacelotheca Yenii** Zundel, nom. nov.

Syn. *Sphacelotheca columellifera* Yen, Rev. Myc. n.s. 2: 76. 1937.

Sori destroying the ovaries and inflorescence, 1–1.5 cm. long, covered by a grey false membrane which ruptures disclosing a powdery spore mass surrounding a thick columella; sterile cells abundant, globose to subglobose, singly or in chains, thick walled, hyaline, 10–21  $\mu$  diam.; spores globose to subglobose, reddish brown, smooth, chiefly 7–9  $\mu$  diam.

On *Andropogon Lanigeri* Desf., Skourat, Morocco, coll. G. Malençon.

VII. USTILAGINALES COLLECTED IN SOUTH EASTERN ASIA

This portion of the paper is to report collections of smuts from South Eastern Asia, which were sent to Dr. George P. Clinton for determination ten or more years ago. The writer found them when going through the Clinton collection of undetermined specimens after his sudden death.

*Ustilago Cynodontis* (Pass.) Curzi, on *Cynodon Dactylon* Pers., along road, Haiphong, Tonkin, Oct. 6, 1921, coll. A. S. Hitchcock (no. 19535); in yard and along street, Vinh, Annam, Indo-China, Sept. 22, 1921, coll. A. S. Hitchcock (no. 19275).  
*Sorosporium Arundinellae* H. & P. Sydow, on *Arundinella Walllichii* Nees, Doniao South of Hanoi, Indo-China, Oct. 4, 1921, coll. A. S. Hitchcock (no. 19464).

*Sorosporium Chamaeraphis* Sydow, on *Chamaeraphis muricata* (L.f.) Merr., Manila, Luzon, Philippine Islands, June 8, 1921, coll. A. S. Hitchcock (no number).

**Sorosporium Cantonensis** Zundel, sp. nov.

Sori destroying the inflorescence, long, linear, about 1 cm. long and 1 mm. wide, hidden by the glumes, the protruding end hardly visible, covered by a membrane which disintegrates into long

sterile cells which often adhere end to end forming hyphae like structures, revealing a granular spore mass surrounding a well developed columella; spore-balls subspheric to elliptic, opaque, many spored, usually disintegrating at maturity, 52–115  $\mu$  long; spores dark reddish-brown, opaque with a thick epispore, chiefly subspheric, irregular, often angular, smooth, chiefly 14–18  $\mu$  in length.

Soris inflorescentiam destruentibus, longis, linearibus, ca. 1 cm. longis et 1 mm. latis, in glumis fere celatis, membrana tegente in longas sterilesque cellas saepe hyphoide catenatas rumpente; massa sporarum granulata maturae columellae circumstante; glomerulis sporarum sub-sphericis vel ellipsoideis, opacis, sporis numerosis, plerumque mature dissolutis, 52–115  $\mu$  longis; sporis atrorubrobrunneis, opacis, episporiis crassis, plerumque subsphericis, irregularibus, saepe angularibus, levibus, plerumque 14–18  $\mu$  longis.

On *Cymbopogon hematatus*, Yinktak, on North river, 80 miles north of Canton, China. Coll. A. S. Hitchcock (no. 18822), Sept. 9, 1921.

This species apparently is related to *Sorosporium geminellum* H. & P. Sydow & Butler, but differs in having a smaller and more slender sorus. The spores of both species are similar in size and shape but are entirely smooth in the species here described.

*Sphacelotheca borealis* (Clint.) Schell., on *Polygonum* sp., flats along river, 6 miles S.E. Harbin, Manchuria, June 17, 1925, coll. P. H. Dorsett (no. 3319).

***Sphacelotheca Hainanae* Zundel, sp. nov.**

Sori in the ovaries, elongated, about 2 mm. long, hidden by the glumes, at first covered by a light colored membrane which ruptures revealing a dark brown spore mass; sterile cells in groups, often cerebroid, yellowish, globose-angular, 7–12  $\mu$  diameter; spores globose to subglobose, regular, light reddish-brown, abundantly and finely echinulate, chiefly 8–10  $\mu$  long.

Soris in ovariis, elongatis, ca. 2 mm. longis, glumis celantibus, membrana albidā, quae rupta massam atreo-brunneam sporarum detegit; cellis sterilibus et glomeratis, saepe cerebroideis, subflavis, globoso-angularibus, 7–12  $\mu$  diam.; sporis globosis vel subglobosis, regularibus, sub-rubro-brunneis, abundante et minute echinulatis, plerumque 8–10  $\mu$  longis.

On *Ischaemum rugosum* Salisb., Kachek, Island of Hainan, China. Coll. A. S. Hitchcock (no. 19610), Oct. 13, 1921.

This species is closely related to *Ustilago tonglinensis* Tracy & Earle, but differs by the smaller, lighter colored spores and in being a *Sphacelotheca*.

## VIII. NEW REPORTS OF NORTH AMERICAN USTILAGINALES

*Cintractia caricis* (Pers.) Magn. on *Carex aquatalis* Wahlb., swamp near Sooke Lake, Vancouver Island, B. C., Aug. 7, 1899, coll. M. A. Barber (no. 59), from Farlow Herbarium, Harvard University; Kalispell Creek, Priest Lake, Bonner Co., Idaho, August 5, 1934, coll. J. H. Christ.

*Ustilago chloridicola* P. Henn. on ? *Chloris radiata* (L.) Swartz, Jamaica, British West Indies, Feb. 14, 1891, coll. R. Thaxter (acc. no. 78814) from Farlow Herbarium, Harvard University.

*Ustilago striaeformis* (West.) Niessl, on *Poa trivialis* L., New Haven, Conn., 1887–1888, coll. R. Thaxter (acc. no. 7888) from Farlow Herbarium, Harvard University; on *Phalaris arundinacea* L., Kitterary Point, Maine, coll. R. Thaxter (acc. no. 7892), from Farlow Herbarium, Harvard University.

*Ustilago utriculosa* (Nees) Tul., on *Polygonum* sp., New Haven, Conn., 1887–1888, coll. R. Thaxter (acc. no. 7886), from Farlow Herbarium, Harvard University.

**Sphacelotheca Digitariae** (Kuuze.) Clinton & Zundel, nom. nov., on *Digitaria horizontalis* Willd., near Kingston, Jamaica, British West Indies, 1891, coll. R. Thaxter (acc. no. 7885), from Farlow Herbarium, Harvard University.

**Tilletia oklahomae** Zundel, sp. nov.

Sori in the ovaries, inconspicuous, concealed by the glumes, 3–4 mm. long, dark colored, sterile cells or immature spores rather abundant, hyaline, thick walled with granular contents, about the size of the spores; spores reddish-brown, regular, sphaerical to subspherical, densely covered with pointed spiney scales (about  $2.5\text{--}3\ \mu$ ), chiefly  $17\text{--}21\ \mu$  in diam.

Soris in ovariis parum conspicuis, glumis celantibus, 3–4 mm. longis, fuscis, cellis sterilibus vel sporis immaturis aliquantum abundantibus, hyalinis, parietibus crassis, granulis internis, eadem ferme magnitudine qua sporis; sporis rubro-brunneis, regularibus, spheroidis vel subspheroidis, spinatis squamis (ca.  $2.5\text{--}3\ \mu$  largis) dense copertis, plerumque  $17\text{--}21\ \mu$  diam.

On *Aristida longespica* Poir., Tulsa, Oklahoma, coll. Mrs. Harriet Barclay, Nov. 1937, comm. W. W. Diehl.

*Urocystis occulta* (Wallr.) Rab., on *Scale cereale* L., New Haven, Conn., 1887–1888, coll. R. Thaxter (acc. no. 7887), from Farlow Herbarium, Harvard University.

## IX. NEW SPECIES FROM VARIOUS PARTS OF THE WORLD

**Sphacelotheca Botriochloae** Zundel, sp. nov.

Sori in the inflorescence, destroying it, long linear, 4-6 cm. long, covered with a dark brown to reddish false membrane which ruptures revealing a dark reddish brown, powdery, spore mass surrounding a well developed, simple columella; sterile cells chiefly globose to somewhat angled by compression, single or in groups, tinted brown, 10-14  $\mu$  diam.; spores chiefly globose to ellipsoidal, sometimes angled, reddish-brown with a thick darker colored episporium, minutely echinulate, 7-8  $\mu$  in diam.

Sori inflorescentiam destruentibus, longis, linearibus, 4-6 cm. longis, membrana falsa atro-brunnea vel rufa, quae rupta massam atro-rubro-brunneam atque pulverulentam sporarum, maturam simplicemque columellam circumcludentem, detegit; cellis sterilibus, plerumque globosis vel aliquantulum per compressionem angularibus, singularibus vel glomeratis, brunneis, 10-14  $\mu$  diam.; sporis plerumque globosis vel ellipsoideis, interdum angularibus, rubro-brunneis, episporio crasso et atriore minute echinulatis, 7-8  $\mu$  diam.

On *Botriochloa decipiens*, Walla Walla, New South Wales, Australia, coll. R. A. Black, May 17, 1937.

**Sphacelotheca nankinensis** Zundel, sp. nov.

Sori destroying the inflorescence, long, linear, chiefly 8-10 cm. long, mostly concealed by the sheaths, covered by a dark brown membrane which flakes away revealing a dark brown, dusty spore mass surrounding a long columella; sterile cells abundant and in groups, tinted light yellow, variable in size, 24-70  $\mu$  long, spores spheric to subspheric, regular, light reddish-brown, smooth, chiefly 4-6  $\mu$  long.

Sori inflorescentiam destruentibus, longis, linearibus, plerumque 8-10 cm. longis, plerumque in vaginis celatis, atro-brunnea membrana tectis; membrana rupta atro-brunneam sporarum massam longae columellae circumstantem detegit; cellis sterilibus glomerulatis abundantibus; sub-flavidis; in magnitudine variabilibus, 24-70  $\mu$  longis, sporis sphericis vel sub-sphericis, dilute rubro-brunneis, levibus, plerumque 4-6  $\mu$  longis.

On *Imperata arundinacea* Cyrilli, Kee-ling Sze, Nanking, prov. Kiangsu, China, coll. by G. N. Stewart, com. by R. H. Porter (no. 265).

This smut differs from *Sphacelotheca Schweinfurthiana* (Thüm.) Sacc. by the smaller, lighter colored spores and by the large groups of sterile cells which are very characteristic. The sterile cells are usually in sub-spheric groups which give a cerebral



appearance, or sometimes they are in long chains having the appearance in general of a braided rope.

**Sphacelotheca Papuae** Zundel, sp. nov.

Sori destroying the ovaries, 2 mm. long, protected by the glumes, at first protected by a delicate membrane, columella well developed; sterile cells usually in groups, globose or frequently collapsed, often irregular, hyaline, thin-walled,  $14-18\ \mu$  diam.; spores reddish-brown, globose or slightly subglobose, regular, minutely but abundantly verruculose, chiefly  $9-10\ \mu$  diam.

Soris ovaria destruentibus, 2 mm. longis, glumis protegentibus, primo membrana delicata tectis, columella bene aucta, cellis sterilibus, plerumque in glomerulis, globosis vel frequenter collapsis, saepe irregularibus, hyalinis, parietibus tenuibus,  $14-18\ \mu$  diam.; sporis rubro-brunneis, globosis vel leviter subglobosis, regularibus, minute sed abundanter verruculosis, plerumque  $9-10\ \mu$  diam.

On *Saccharum arundinacea* Retz., on Fly River, 30 miles below Everill Junction, Papua (British New Guinea), coll. Brass (no. 6582, Archbold Expedition), May 1936.

This species is closely related to *Sphacelotheca Schweinfurthiana* (Thüm.) Sacc., but differs in having verruculate spores while the spores of *S. Schweinfurthiana* are smooth.

**Sphacelotheca Viegasiana** Zundel, sp. nov.

Sori destroying the inflorescence, partially concealed by the sheath; 2-5 cm. long, covered by a brown membrane which disintegrates revealing a dark brown, powdery spore mass surrounding a thick columella, sterile cells of false membrane at first in chains but later disintegrating into pairs or singly, subglobose to ellipsoidal, hyaline,  $7-14\ \mu$  long; spores globose to subglobose, regular, olivaceous-brown, smooth, chiefly  $7-8\ \mu$  in diam.

Soris inflorescentiam destruentibus, partim vagina celatis, 2-5 cm. longis, membrana brunnea, massa sporarum atro-brunnea pulverulenta, columella crassa, cellis membranae falsae sterilibus primo in catenas, deinde binatim vel singulatim disintegrantibus, subglobosis vel ellipsoideis, hyalinis,  $7-14\ \mu$  longis; sporis globosis vel subglobosis, regularibus, olivaceo-brunneis, levibus, plerumque  $7-8\ \mu$  diam.

On *Trichachne saccariflora* (Raddi) Nees, Terreno baldio, Campinas. Est. S. Paulo, Brazil, coll. A. P. Viegas, Oct. 5, 1935 (no. 2554).

**Sorosporium Yoshinagae** Zundel, sp. nov.

Sori destroying the inflorescence, long, linear, 6–9 cm. long, at first concealed by the sheaths and covered with a delicate membrane which flakes away revealing long shreds and a dark brown spore mass which soon becomes powdery; spore-balls rather evanescent, regular, ovate, opaque, dark brown with numerous spores, chiefly 70–105  $\mu$  long; spores reddish-brown, spheric to subspheric, smooth, chiefly 4–6  $\mu$  in length.

Soris inflorescentiam destruentibus, longis linearibus, 6–9 cm. longis, primo membrana delicata in vagina tectis, quae membrana rupta fibrillas longas et massam atro-brunneam mox pulverulentam sporum detegit; glomerulis sporum aliquantulum evanescentibus, regularibus, ovatis, opacis, atro-brunneis, sporas numerosas habentibus, 70–105  $\mu$  longis; sporis atro-brunneis, spheroides vel sub-spheroides, levibus, plerumque 4–6  $\mu$  longis.

On *Panicum repens* L., Trino-mura, Tosa, Japan. Coll. by T. Yoshinaga, Aug. 8, 1922.

**Cintractia nova-guineae** Zundel, sp. nov.

Sori in the ovaries, rather completely hidden by the glumes, oblong to subspherical, 3–5 mm. long, somewhat agglutinated to powdery; spores globose to subglobose or sometimes subcircular by mutual compression, intermixed with reddish-brown, collapsed host cells, dark reddish-brown, usually with remains of enveloping membrane showing as hyaline to brown lateral wings, minutely pitted, 17.5–21  $\mu$  diam.

Soris in ovariis, glumis paene omnino celatis, oblongis vel subspheroides, 3–5 mm., aliquantulum agglutinatis vel pulverulentis; sporis globosis vel subglobosis, interdum per compressionem inter se subcircularibus, rubro-brunneo colore intermixtis, cellis hospitis collapsis, atro-rubro-brunneis, plerumque partibus membranae restantibus, velut hyalinis vel brunneis lateralibus alis apparentibus, minute porosis, 17.5–21  $\mu$  diam.

On *Rhynchospora aff. glauca*, Marsh Meadows, Morobe, New Guinea, coll. Mrs. Clemens, Dec. 22, 1938. Comm. Dr. George B. Cummins.

This smut is closely related to *Cintractia amazonica* Sydow, but differs by having a larger sorus and by having the spores minutely pitted while the spores of *C. amazonica* are verruculate. Some *Juncus* sp. was mixed in the collection.

## HOST INVASION IN SYSTEMIC INFECTIONS OF *UROMYCES CALADII*

S. M. PADY \*

(WITH 3 FIGURES)

*Uromyces Caladii* is a systemic perennial rust on *Arisaema triphyllum*, the well known and widely distributed Jack-in-the-pulpit, and on *A. Dracontium*, Dragon Root. Leaves and flower parts show evident infection as they unfold in the spring with pycnia covering the lower surface of the leaves, the spathe and often the spadix as well, followed later by the aecia. In this autoecious rust the uredinia are formed during the summer in localized infections, followed by the telia which either replace the uredinial pustules, or form in separate sori.

For some time the writer has been interested in some of the rusts which are systemic and perennial: *Hyalopsora aspidiotus*, whose diploid mycelium systemically infects the fern, *Phegopteris* (6); *Calyptospora Geoppertiana*, whose haploid systemic mycelium causes Witches Brooms on blueberries (5); *Gymnoconia interstitialis*, the well known Orange-rust of wild and cultivated blackberries (7). This paper presents the results of observations made in connection with the study of the distribution of the mycelium of *Uromyces Caladii* in the dormant and the growing tissues of *A. triphyllum*.

Freehand and prepared sections through dormant infected corms reveal the presence of mycelium in practically all of the tissues. The lower half of the corm, which is relatively free from starch, contains a much greater amount of mycelium than the upper starch-filled region. The mycelium is typically intercellular with moderately broad uninucleate hyphal cells filled with dense cytoplasm. In certain regions the mycelium is especially abundant and the host

\* The writer takes this opportunity of thanking Dr. G. W. Keitt, Head of the Department of Plant Pathology, University of Wisconsin, and other members of the staff, for courtesies generously extended during the summer of 1937.

cells may be almost completely surrounded by hyphae, with numerous slender coiled haustoria projecting into adjacent cells. These areas usually involve about a half a dozen or more of the large parenchymatous cells and are found only in the lower half of the corm. In many cases the mycelium evidences a preference for the vascular bundles, often being found in close association with the vascular elements. The upper part of the corm consists of a large smooth conical bud made up of a median growing point completely enclosed by two rudimentary leaves, one inside the other, and four outer fleshy bracts. If the corm is large enough to produce flowers a rudimentary flowering stalk will be formed immediately above the growing point. All of these structures may contain mycelium. Large corms may bear one or more offsets on the upper margin and these also have been shown to possess mycelium in all tissues.

When growth begins in the spring the mycelium keeps pace with the growing tissues as indicated by the presence of hyphae in the above-ground parts. Three of the bracts remain rudimentary while the fourth grows large enough to protect the leaf as it pushes through the soil, remaining at the base as a membraneous sheath (8). Invasion of this bract is evidenced by the later appearance of pycnia and sometimes aecia. At this time long white fleshy roots, often terminating in offsets, arise from the upper surface of the corm penetrating the soil for a considerable distance. Preliminary examination of these roots failed to reveal any trace of mycelium. A careful study of prepared slides made from similar roots has confirmed this observation. If the mycelium invades the root at all it must be when the root is beginning to form, because older roots are certainly free from the rust. In this case, the host tissues have outgrown the fungus. There is also the possibility that the mycelium does not invade even the youngest roots.

#### MYCELIUM IN THE PETIOLE OF THE LEAF

The mature leaf of *Arisaema triphyllum* is a large tri-radiate structure with a stout petiole, which may reach a height of 24" or more. The petiole consists of an outer epidermis followed by several layers of fairly compact parenchymatous cells. From this point, progressing toward the center are found many large air spaces which give the central part of the stalk a spongy appearance.

This spongy parenchyma is characteristic and is "of a special and peculiar form, in which the cells are arranged to make a series of fluted columns" (1). The large air spaces formed by these columns constitute an ideal growing region and mycelium is very abundant here. Occasionally, the fungus invades the scattered bundles; but more often is found in the parenchyma immediately surrounding the bundle. Another favorite region is in the intercellular spaces of the cells which lie just beneath the epidermis. The amount of mycelium present in a petiole is extremely variable, ranging from a condition where the distribution is relatively uniform to one where the hyphae occur only in a few isolated patches.

#### MYCELIUM IN THE LEAF BLADE

Lesions of various sizes characterize the upper surface of infected leaves. These lesions vary from pale yellowish-green to whitish in color, and form a striking contrast to the disease-free tissues (FIG. 1). It has been found that these areas represent very accurately the extent of mycelial invasion and that the mycelium is confined to these areas. The precise limits of the infected tissues may be readily determined, as well as the percentage of infection. While only a few percentages have been accurately worked out, it is possible to arrange infected leaves in a graded series which would demonstrate all degrees of infection from a trace to one hundred percent. Sometimes one leaflet alone will be infected, while the other 2 leaflets are free. In most cases, however, where one leaflet shows infection the others also will show it (FIG. 1). Where the percentage of infection is low the infected areas are invariably confined to the regions immediately bordering the mid-rib of the leaflet, and usually extend the entire length of the blade. These areas are extremely irregular and often extend out into the adjacent mesophyll as whitish projections of varying lengths and widths. The leaf shown in figure 1 demonstrates this very clearly, the lesions being confined to the mid-rib region and extending to the tip of each leaflet, while in 3 places the lesions extend all the way to the margin.

In order to estimate the percentage of infection in the leaf shown in figure 1, the outline of the leaf was traced on squared graph paper. The infected areas were very carefully outlined by the same

method. The total area of all 3 leaflets was found to be 7800 sq. mm.; the total infected area was 2112 sq. mm.; the percentage of infection was 27.0 per cent. The individual leaflets had the following percentages: Leaflet 1 (on the right) 16.8 per cent, Leaflet 2 (top) 46.7 per cent, Leaflet 3 (at left) 31.3 per cent.

The photograph in figure 1 also shows clearly another effect upon leaf tissues, namely that of distortion. The presence of mycelium retards the normal ontogeny of leaf tissues and the infected areas are generally much smaller and as a result the leaf is usually very

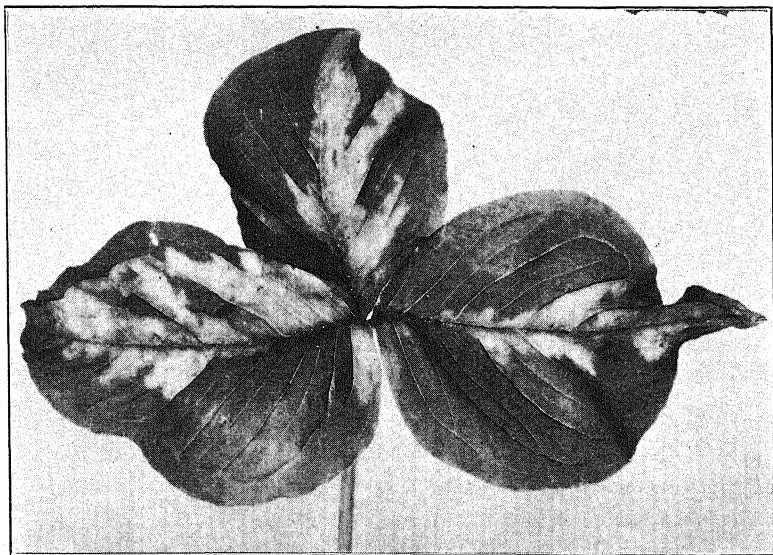


FIG. 1. Leaf of *Arisaema triphyllum* infected with *Uromyces Caladii*.

irregular in outline. This stunting effect becomes clear when the infected areas are compared with the disease-free tissues. For example, the lower halves of the 2 basal leaflets in figure 1, which are practically disease free, are appreciably larger than adjacent infected areas. This is even more clearly shown where one or two leaflets are heavily infected, while the remaining leaflets are relatively free. In such cases the diseased leaf is not only distorted but is greatly reduced in size. This is shown by the following figures obtained from a partially infected leaf. Leaflet 1 was free from the rust and had a total area of 5036 sq. mm.; Leaflet 2 with

54.8 per cent infection had an area of 3372 sq. mm.; Leaflet 3 with 53.4 per cent infection had an area of 3500 sq. mm. The disease free leaflet thus had an increased surface area of between 1664–1738 sq. mm. Leaves with a high percentage of infection are greatly reduced in size and shape, the latter changing from the normal lanceolate to an irregular oval or round, and the tip from long acuminate to mucronate.

The mycelium in the leaf tissue is confined largely to the spongy parenchyma, although both epidermis and chlorenchyma are infected. In leaves which are partially infected the mycelium is often delimited by the large veins which run out pinnately from the midrib. These large veins appear to be an effective boundary (FIG. 1, left leaflet). Pycnia are formed on the lower surface in the substomatal air chambers and in their vicinity the mycelium is particularly abundant, as Rice has pointed out (9). Aecia are formed in the spongy parenchyma and in the neighborhood of the aecial primordia the mycelium is also abundant.

#### MYCELIUM IN THE FLOWER

The flower bud arises inside the two leaf primordia and grows out through the petiole a short distance above the axil of the 2 leaves about the same time as the leaves are unfolding. The mycelium which was in the growing point has grown rapidly in the young flower stalk keeping pace with the host tissues. The spongy nature of the stalk and of the spathe and spadix provides ideal conditions for rapid mycelial growth. Freehand and prepared sections of both the stalk and spadix reveal abundant mycelium in the large open spaces between the columns. Almost immediately pycnia may be observed on the spathe and on the flower stalk; later, these will be followed by aecia.

The spadix consists of a central axis made up of the spongy parenchyma mentioned earlier, terminated by a large sterile club-shaped structure usually purple in color and subtended by the stamens and ovaries. *Arisaema* is usually dioecious with the staminate and pistillate flowers on separate plants. In both cases the flowers are in a cluster at the base of the spadix, usually separated from the upper sterile portion by a narrow neck. The filaments are short and bear the anthers at the tip, these having four

small locules. Mycelium is present in the filament and in the portion of the anther lying between the locules, but none has ever been found in the tapetum, spores or locules. Occasionally pycnia are present on the sterile club and they have been found also on the filaments of the stamens.

The ovulate flowers consist of single unilocular gynaecia, clustered about the base of the spadix. In each ovary 5 orthotropus ovules are formed arising from the placenta. The tip of the ovary is somewhat conical and is surmounted by a stigma consisting of elongated unicellular cells resembling young root hairs. Figure 2A is a section of a young flower in the megaspore mother cell

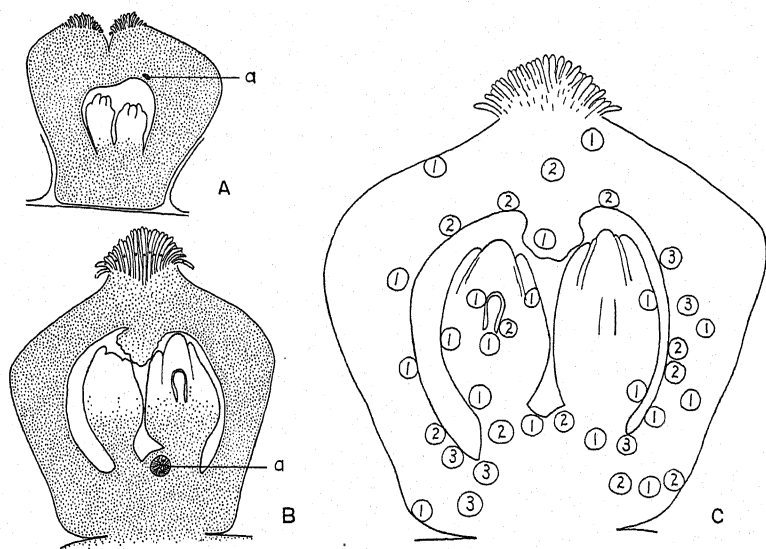


FIG. 2. *Uromyces Caladii*.

stage, with young stigma, styler canal and 2 ovules each with a megaspore mother cell, nucellus and an outer and inner integument. Figure 3A is a photomicrograph of an ovulate flower of the same age.

The distribution of the mycelium in the young ovary is shown diagrammatically in Figure 2A by the stippled areas. All tissues except those of the ovule contain fungus hyphae. While some variation exists, the mycelium at this stage has reached a point midway up the funiculus. This shows very clearly in the slide



from which figure 3*A* was taken; in the photograph, however, the mycelium cannot be clearly seen. Evidently the ovules grow very rapidly and for a time at least outstrip the fungus, although the mycelium actually does invade the ovule later. In ovaries of this stage, that is, the megaspore mother cell stage, pycnia may begin to form and the tiny rudiments may often be found, as for example in figure 2*A*, *a*. Such cases are indeed rare and have been observed only 3 times, twice in the ovule wall (FIG. 2*A*, *a*), and once in the centre of the ovule at a point much higher than the line indicated in figure 2*A*.

#### INTERNAL PYCNIA IN OLDER OVULES

During the summer of 1937 a number of infected plants were grown in the greenhouse, of which there were several staminate and pistillate plants. The particular plant which furnished the material for the study of older ovules was one of 2 remaining pistillate plants. Artificial pollination was employed in order to ensure fertilization, the pollen being transferred by means of a camel's hair brush. Eight days later the material was fixed and studied. From the condition of the embryo (FIG. 3*B*, *D*) it is evident that the pollination was successful, although it is difficult to determine whether it was due to natural or to artificial pollination.

A comparison of figures 2*A* and 2*B* or of the photographs 3*A* and 3*B* shows clearly the tremendous increase in size of all parts of the ovary and especially of the ovule. The mycelium has grown up into the developing ovule reaching the nucellus and integuments (FIG. 2*B*). No instance of mycelium in the tip of the ovule has ever been observed. The fungus threads are well filled with cytoplasm and appear to be growing rapidly. Mature and developing pycnia are abundant (FIG. 3*B*, *C*, *D*, *E*). The number of pycnia per ovulate flower averages 5-8; in the flower shown in section, in figure 3*B*, three other pycnia were present, making a total of five. Except for the smaller size and the loss of paraphyses these pycnia appeared quite normal. Spermatophores line the cavity projecting toward the centre (FIG. 2*B*, 3*D*, *E*). Occasionally spermatia were exuded into the surrounding tissues (FIG. 3*B*). Where the pycnia opened into the locule, some paraphyses

were present and spermatia occurred in abundance. The latter appeared quite normal, at least insofar as staining was concerned.

Figure 2C is a diagrammatic summary of the number and distribution of these pycnia. All of the pycnia found in 12 ovaries were counted and their position was marked by a circle; the number appearing in that region was designated by a figure inside the circle. An analysis of figure 2C is found in Table I.

TABLE I  
ANALYSIS OF FIGURE 2C

Total number pycnia checked.....	59
Deep seated abnormal.....	41
Pycnia near edge (FIG. 3B) but never opening to outside.....	9
Pycnia projecting into locule.....	14
Pycnia opening to outside.....	4
Pycnia in ovule (FIG. 3F).....	7 (11%)
Pycnia in funiculus (FIG. 3C, D, E).....	3 (5%)
Pycnia in placenta (FIG. 2B, 3B).....	12 (20%)
Pycnia in ovary wall (FIG. 3C).....	37 (64%)

Another explanation of the rapid invasion of the ovule by the mycelium is by lateral infection from the ovary wall instead of basal infection through the funiculus. In many cases (FIG. 3A, E, F) the ovule is very close to the ovary wall. Where actual contact occurred it would be relatively easy for the mycelium to enter the integument. Some of the ovaries of the material used in working out figure 2C were sectioned transversely and revealed 5 rather crowded ovules. In one case a young pycnial fundament was present in the integument at the nearest point to the ovary wall. Running from the fundament were several strands of mycelium which could be clearly traced to the ovary wall. This explanation might also account for the pycnium found in the very young ovule referred to earlier.

The presence of small pycnia in the ovule (FIG. 3F) proves that the mycelium invades this tissue very rapidly and soon forms fruiting bodies. The important question here is whether the young embryo contains mycelium or not. A study of many sections failed to reveal any signs of hyphae. Since the embryo has arisen from the fertilized egg cell and has grown very quickly it would become infected only when mycelium was present in the embryo sac or in great abundance in the nucellus. The chances

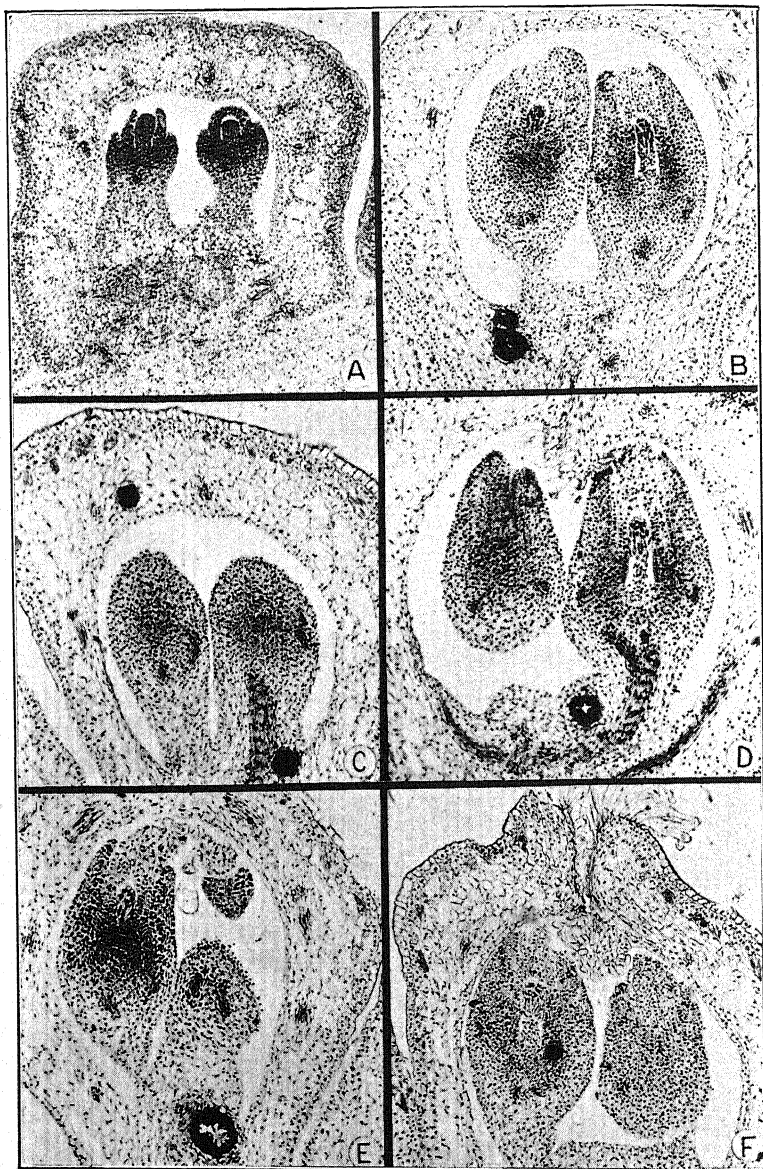


FIG. 3. Infection in *Uromyces Caladii*.

of the very young embryo becoming infected are thus very slight, although the surrounding tissues may be heavily infected. It would require a very rapidly growing mycelium to invade the young embryo.

Nine pycnia have been found in the older ovule (FIG. 2C) of which 4 were deeply seated in the tissues immediately surrounding the nucellus (FIG. 3F). One occupied a position in the nucellus about the level of the tip of the embryo; 2 were situated in the tissues opposite the base of the embryo; while the 4th lay immediately below the basal part of the embryo. In 3 of these the pycnium projected slightly into the space between the nucellus and the embryo.

#### MYCELIUM IN THE SEED

Considerable time and effort have been spent in studying seeds for the presence of the fungus, but results to date have been inconclusive. It should be borne in mind that systemically infected plants rarely flower and produce seed (4). This is partly true of *Arisaema* but there are several cases where systemically infected plants have produced seeds. The writer is of the opinion that the seeds may and do transmit the disease. This belief is based on the fact that the mycelium invades the young ovules and is present at the base of the young embryo. Further evidence was found in one plant, no. 48, which produced flowers in the greenhouse. This plant was pollinated to ensure fertilization. Twenty-two days later the fruit was harvested and young seeds showed unmistakable signs of infection.

Conclusive proof necessitates finding mycelium in mature seeds in plants grown under natural conditions. Numerous collections of seeds have failed so far to reveal any signs of mycelium. This problem will be further studied during the coming growing season.

#### OBSERVATION ON GROWTH OF DISEASED CORNS

It was decided to study the behavior of infected plants over a period of a number of years.<sup>1</sup> Large numbers of plants were gathered in the spring of 1936 and potted. During the summer of 1937 these corns were grown in the greenhouse of the Depart-

<sup>1</sup> Problem suggested by Professor H. S. Jackson, University of Toronto.

ment of Plant Pathology, University of Wisconsin. Corms were planted in individual pots on June 5th, 1937, and careful observations were made on the time required (1) for pycnia to appear, (2) for aecia to be formed. *Arisaema triphyllum* is a cool weather shade plant and great difficulty was encountered in keeping the plants growing, due to the high temperatures and other unfavorable conditions in the greenhouse. Many of the corms failed to germinate and the mortality among those that did grow was very high. The following table summarizes the observations made on the remaining plants:

TABLE II  
LENGTH OF TIME REQUIRED FOR PYCNIAL AND AEICIAL STAGES TO APPEAR  
WHEN GROWN UNDER GREENHOUSE CONDITIONS

No. of days after planting.....	16	19	23	26	30	33	37	40	44	47
Plants showing pycnia.....	21	55	45	42	35	37	33	31	28	27
Plants showing pycnia and aecial fundaments.....	0	3	20	26	32	30	31	32	31	29
Plants showing pycnia and aecial sori.....	0	1	1	2	5	7	6	5	5	4
Total infected plants.....	21	59	66	70	72	74	70	69	64	60
Total plants dead or dying or failed to grow.....	—	—	—	—	—	28	32	33	37	42

At the end of 16 days 21 plants showed aecia. By the 19th day 55 plants showed aecia, 3 additional plants showed aecial fundaments and 1 plant had a few aecia. On the 23rd day 45 plants were in the pycnial stage and 20 had developed aecial fundaments. From this time on there was a gradual increase in the number of plants showing aecia, and aecial fundaments. Pycnia continued to appear up to about the 33rd day. Many plants remained in the pycnial stage for the entire period. Many others developed fundaments, but failed to produce sori. The mortality is indicated by the figures in the 6th row.

#### DISCUSSION

Systemic infections imply invasion of all tissues in certain parts of a plant. Theoretically it is possible for a plant to become so completely parasitized that no part is free from the fungus. Actually such cases are extremely rare, even in the systemic rusts which are perennial. Arthur (2) uses the term "systemic" to apply to invasions of a portion of the plant. In *Melampsorella elatina* the fungus is confined to the tips of certain branches giving a witches

broom effect and causing the new leaves and shoots produced each spring to be infected. Here the infection is clearly systemic but only a part of the host is involved.

*Uromyces Caladii* is unusual in that the entire plant, with the exception of the roots, may be systemically infected. The effects of such infection are found in the tendency to suppress sexual reproduction, distortion of the leaves, and in the shortening of the growing period. Rapidly growing tissues may outgrow the fungus. In *Arisaema* the roots of infected plants are regularly free from the rust, and this in all probability is due to very rapid growth early in the season when conditions are favorable. In blackberries systemically infected with *Caeoma nitens*, sporulation begins early in the growing season and ordinarily all leaves are heavily rusted. The writer has observed that new leaves forming at the tip of the shoot, at the time the fungus is beginning to sporulate, are usually free from the rust. Part of the explanation doubtless lies in the fact that the host tissues have simply outgrown the fungus, since the leaves are devoid of hyphae; part of the explanation seems to involve the following fundamental principle. Two definite phases of growth are distinguishable in this systemic perennial mycelium. The first phase is that of *vegetative growth* and the establishment of the mycelium in the host. This takes place while the host tissues are developing at the beginning of the growing season. As the host tissues mature the fungus begins the second phase, namely *reproduction*, and sporulation commences. The onset of the second phase marks the end of the vegetative growth, and subsequently the mycelium does not invade new host territory. In *U. Caladii* disease free portions of the leaf will not be invaded after pycnia and aecia appear. In *C. nitens*, leaves formed during the first phase would be rusted but leaves formed during the second phase while sporulation was taking place would be free from the rust.

The percentage of infection is the measure of success achieved by the rust during the first phase of growth. One factor which would aid materially is the amount of mycelium originally present in the leaf primordium. Abundant hyphae would tend to result in a high percentage of infection. Sections through petioles show a great variation in the amount of mycelium; heavily infected leaves have plenty of mycelium; lightly infected leaves show only

occasional strands. The amount of mycelium therefore in the leaf would be dependent upon the amount of mycelium in the leaf primordium. There is evidently a very definite correlation between the percentage of infection and the amount of mycelium in the dormant corm. Numerous factors would influence the relative abundance of mycelium; the amount of growth made by the host the previous year; the amount of growth made by the fungus; the number of years infected; the age of the corm when primary infection occurred. The susceptible period is certainly very short since it is a common sight to see one heavily infected plant completely surrounded by healthy individuals. From such a plant there would be sufficient inoculum to infect every healthy plant in that immediate vicinity. In order to become systemic the mycelium must become established in the growing point of the corm. It has been shown by Dodge (4) and also by Pady (7) that the susceptible period for blackberries is just as the shoot pushes through the ground. If basidiospores of *C. nitens* fall on the shoot at this time the mycelium will invade the crown and in the following spring will be found in the growing points. One reason for the ease with which blackberries are infected is that the crown is very close to the ground level and the distance the mycelium will have to travel during that first year is very short. Arber (2) and Rennert (8) have shown that the corms of *Arisaema* tend to become deep seated as the result of the action of the contractile roots. Basidiospores falling on the shoot at the ground level would have to invade the corm, several inches away, before the above ground parts die off. Doubtless many plants become infected with basidiospores, but the majority will likely remain as local infections dying off at the end of the growing season. The growing season for *Arisaema* is very short and this would tend to make infection even more difficult. Part, if not all, of the explanation for the paucity of primary infections lies in the fact that the corms normally do not remain near the surface of the ground.

Arthur's (2) theory that the orientation of sori is controlled by nearness to the surrounding atmosphere, due to diffusion of air through stomata or epidermis, is probably correct. Normal pycnia of *U. Caladii* are substomatal and may be explained on this basis. In explaining the change of orientation of deep seated sori Arthur

postulated the presence of nearby cavities or locules in the tissues which cause the sori to grow toward them. The internal pycnia described by Stampfli (10) for *U. pisi* are all projecting into the locules of the flower. In *U. Caladii* however, there are more deep seated pycnia than there are those which open to the locules or to the atmosphere. Obviously, Arthur's explanation does not hold for *U. Caladii*. The theory that internal sori follow the line of least resistance (3) (11) does not apply to this particular rust since about 36 per cent of the pycnia lie in the compact tissues of the placenta, funiculus and ovule. The high percentage of internal pycnia in the ovary wall (64 per cent) is probably due to the fact that this tissue is the older and the hyphae had an excellent opportunity of becoming established there. The next oldest tissues are those of the placenta region (2) and the number of pycnia is correspondingly greater than in the relatively young tissues of the ovule.

It is surprising that there are so few pycnia on the outer surface of the ovary, since this tissue was not expanding any more rapidly than the tissues which contain the internal pycnia. Many of the pycnia lie so close to the surface that it would be relatively easy for them to force apart the overlying tissues. The upper pycnium in figure 3B lies but one cell below the cavity of the locule. Most of the pycnia appear to be functioning, as witnessed by the production of spermatia which are often extruded into the tissues. Modifications of these internal sori lie first in the suppression of the paraphyses and secondly in the occasional reduction of size. The comparison of figures 3E and 3F indicates that often the internal sori reach a considerable size, as large in fact as typical sori of the leaf. All such internal sori are atypical and probably should be regarded "as teratological phenomena of no special morphological significance" (3).

The questions of heterothallism, fertilization and diplodization are still under investigation. The failure of the plants grown in the greenhouse to produce aecia (Table II) may have been due to the unfavorable growing conditions since many plants remained in the pycnial stage. To all outward appearances, however, conditions were favorable, the pycnial nectar was abundant, insects were present and in the mornings the temperature was low and



humidity fairly high. Is it not possible that failure to produce aecia is due to the presence in separate plants of heterothallic races? Monosporidial infections undoubtedly take place in nature. On the other hand, if the perennial mycelium was made up of mixed races, how would fertilization occur? Would diplodization take place through mycelial fusions within the tissues or would there need to be a mixing of nectar from the different kinds of pycnia? In nature many "sterile" plants have already been found and others with but a few aecial sori surrounded by old and dying pycnia. The explanation of these two phenomena is purely a matter of conjecture. *Uromyces Caladii* seems to be favorable material for further investigations along these lines.

#### SUMMARY

Dormant corms of *Arisaema triphyllum* are systemically infected with the haploid mycelium of *Uromyces Caladii*. When growth begins in the spring, leaves and flowers become infected but roots remain free. In the leaf, mycelium is revealed by lesions on the upper surface, from which the percentage of infection may be estimated. The percentage varies from a trace to 100 per cent. In the flower mycelium invades all tissues of the spathe and spadix. Internal pycnia are found in the ovulate flowers, usually 5-8 per ovary and located in the ovary wall (64 per cent), placenta (20 per cent), funiculus (5 per cent), ovule (11 per cent). The mycelium invades the ovule and the young embryo suggesting the possibility of transmission of the disease through the seed.

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#### EXPLANATION OF FIGURES

Fig. 1. Leaf of *Arisaema triphyllum* infected with *Uromyces Caladii*. Total leaf area 7400 sq. mm. Infected area 2112 sq. mm. (28.5 per cent). Photograph by Eugene Herrling.

Fig. 2A. Longitudinal section of young ovary showing two ovules at the megaspore mother cell stage. Stippled area represents the presence of mycelium. Young pycnium shown at *a*. Compare with figure 3A. Camera lucida outline drawing. Fig. 2B. Longitudinal section through ovary 8 days after pollination. Note the developing embryo, internal pycnium at *a*, the invasion of the ovule by mycelium. Compare with figure 3D. Camera lucida outline drawing. Fig. 2C. Diagram of an ovary to show the location of the internal pycnia in the flower. Pycnia are represented by circles and the number inside the circle indicates the number of pycnia found in that region. Of the 59 pycnia shown, 41 are deep seated. Average number of pycnia per ovary is 5-8.

Fig. 3A. Photomicrograph of young infected ovary. Compare with figure 2A. Fig. 3B, C, D, E. Photomicrographs showing internal pycnia in various tissues of the flower. Fixative made 8 days after pollination. Fig. 3F. Young pycnium in nucellus of ovule. (Photomicrographs by Eugene Herrling.)

# STERILE CONKS OF POLYPORUS GLOMERATUS AND ASSOCIATED CANKERS ON BEECH AND RED MAPLE

W. A. CAMPBELL AND ROSS W. DAVIDSON

(WITH 2 FIGURES)

## INTRODUCTION

In 1930 Hirt<sup>1</sup> reported sterile conks on beech (*Fagus grandifolia* Ehrhart.), which were associated with a normal fruiting body of *Fomes Everhartii* (Ellis & Gall.) Schrenk. During the summer of 1938 another type of sterile conk, with or without associated cankers, was found commonly on beech in the Green Mountain National Forest. These sterile conks, except for their smaller size, resembled those on birch recently reported by Campbell and Davidson<sup>2</sup> to be a sterile form of a *Poria* (probably *Poria obliqua*). Because of this resemblance and because *P. obliqua* or a similar *Poria* had been collected on beech in Pennsylvania and New Hampshire, it was originally thought that the sterile conks might be the sterile form of it. However, pure cultures of *Polyporus glomeratus* Peck, described by the writers,<sup>3</sup> were isolated from the sterile conks and the associated decay. In addition, *P. glomeratus* fruited on down beech on which there were sterile conks and cankers.

Later in the season a number of red maples (*Acer rubrum* Linn.) on the Gale River Experimental Forest, New Hampshire, were found to be badly cankered and decayed. Sterile fungus material characteristic of *P. glomeratus* was associated with the cankers and pure cultures from this material and from the decay confirmed the

<sup>1</sup> Hirt, Ray R. *Fomes Everhartii* associated with the production of sterile rimose bodies on *Fagus grandifolia*. *Mycologia* 22: 310-312. 1930.

<sup>2</sup> Campbell, W. A. & Ross W. Davidson. A *Poria* as the fruiting stage of the fungus causing sterile conks on birch. *Mycologia* 30: 553-560. 1938.

<sup>3</sup> Campbell, W. A. & Ross W. Davidson. *Poria Andersonii* and *Polyporus glomeratus*, two distinct heart-rotting fungi. *Mycologia* 31: 161-168. 1939.

diagnosis. Fertile fruiting on down logs was also noticed. Lorenz and Christensen<sup>4</sup> reported *P. glomeratus* cankers to be common on maples in the Lake States but such cankers have not been reported from New England.

#### STERILE CONKS AND CANKERS ON BEECH

A number of beech trees bearing sterile conks of *P. glomeratus* (FIG. 1, *A*, *B*) were cut and dissected. The fungus appeared to infect the trunk chiefly through dead branch stubs, although its association in several cases with trunk wounds could be demonstrated. Infections were particularly common in the upper trunk and the sterile conks were usually seen protruding from knot holes just below the live crown. The decay seemed to progress readily in the heartwood and infections originating in the upper trunk spread down through the heartwood until the entire center of the tree was badly decayed leaving only a narrow ring of sapwood.

Sterile conks frequently formed at old unhealed branch stub openings. These sterile conks, which were obtuse-elongated or flattened, dark brown to black and roughened on the surface from weathering or with rings denoting seasonal activity, rarely protruded more than 3 inches and appeared at first glance to be dead branch stubs (FIG. 1, *B*). In time a decided canker formed on the trunk about the branch stub bearing the sterile conk, and with the appearance and extension of the canker the development of the sterile conk itself seemed to be checked (FIG. 1, *C*). Instead of a marked increase in the size of the sterile conk, sterile fungus material was deposited in the face of the canker so that an ax cut through a canker showed a thick, yellow-brown fungus mass in and beneath the undisturbed bark.

Sterile conks with which no branch stubs were associated were also common, especially on trees badly decayed by the fungus. As the heartwood became decayed the fungus had a tendency to work out through the sapwood often following healed-over branch traces (FIG. 1, *D*). The reaction of the tree in many cases to such outward extension of the decay through the sapwood was to form

<sup>4</sup> Lorenz, Rolland C. & Clyde M. Christensen. A survey of forest tree diseases and their relation to stand improvement in the Lake and Central States. U. S. Dep. Agr. Bureau Pl. Ind. Mimeograph p. 21. 1937.

ridges or fluted areas on the trunk (FIG. 1, *E*). In time the decay sometimes broke through these ridges and a sterile conk formed on the trunk. Later a canker developed around the conk. The development of the sterile conk and canker depended to some extent

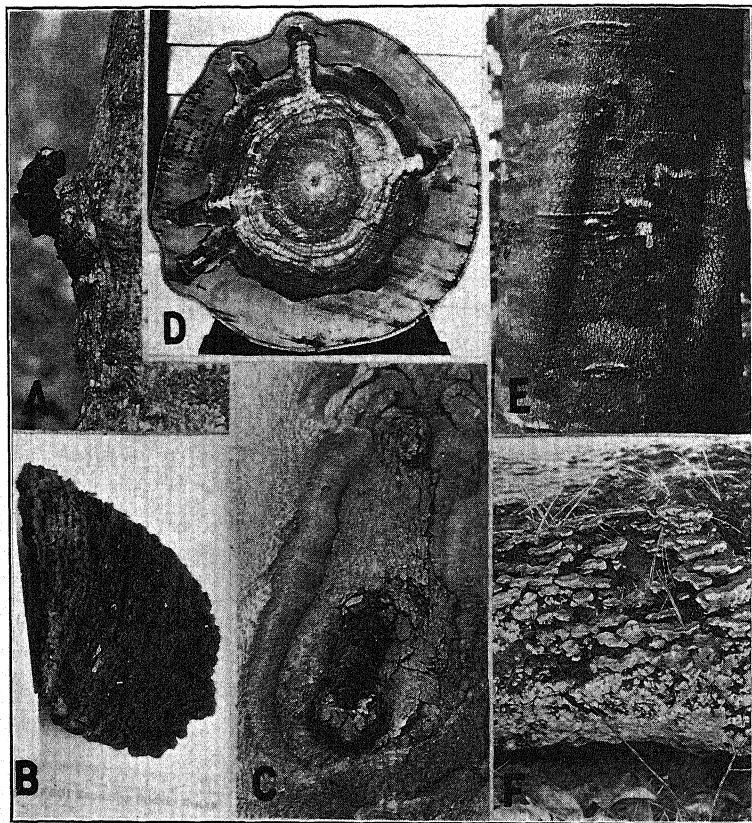


FIG. 1. *Polyporus glomeratus* on beech. *A*, sterile conk on a 5-inch suppressed tree; *B*, sterile conk approximately 3 by 4 inches; *C*, canker showing sterile conk; *D*, cross section of a 15-inch tree decayed by *P. glomeratus* (notice streaks of decay extending into the sapwood); *E*, ridges or fluted areas on trunk; *F*, sporophores of *P. glomeratus* on down log.

on the vigor of the tree. Vigorous, fast-growing trees resisted canker formation and tended to produce more pronounced sterile conks, but slow-growing, non-vigorous trees cankered readily and formed inconspicuous sterile conks.

In most cases the bark did not slough off the surface of the canker but it became much cracked and checked, and the hard yellowish fungus material was deposited in the cracks and beneath the bark itself. These cankers were often very large, especially on old trees, and elongated cankers as much as 2 feet long and somewhat less narrow were not uncommon.

Evidently *P. glomeratus* fruits rarely on living trees. Sporophore formation takes place on the underside of down logs usually several years after the trunk blows over. It occasionally fruits on the side of the upright stump or stub but such fruiting is limited. On the down log the fungus fruits in abundance often forming sporophore masses many feet long on the entire lower side of the trunk (FIG. 1, *F*). The yellowish-green spores are produced in great quantities and often cover the ground and nearby objects with a bright yellowish-green powder.

Sterile conks of *P. glomeratus* are common on the overmature beech in the Green Mountain National Forest, Vermont, and were also found in the White Mountain National Forest, New Hampshire. One sterile conk was collected in Pennsylvania and one in Maine.

#### STERILE CONKS AND CANKERS ON RED MAPLE

*Polyporus glomeratus* was associated with well-defined cankers on red maple particularly in connection with old branch stubs (FIG. 2, *A*). Such cankers usually had a definite hypertrophied margin and a depressed center. The depressed center of the canker was filled with a hard crust-like deposit of sterile fungus material, which was often not greatly different in appearance from the maple bark itself. In many cases the canker face, especially if it originated at a point other than a branch stub, was covered by the apparently undisturbed bark which on examination proved to be impregnated with fungus material. Elongated cankers with hypertrophied margins were not uncommon (FIG. 2, *B*). Cross sections of the stems showed marked distortion and swelling and in the field the disease could be readily recognized by the peculiar swollen, often protruding, branch stubs and cankers. Multiple cankers on old red maples often caused large distorted areas on the stem (FIG. 2, *C*).

Definite protruding sterile conks such as were common on beech were rare on red maple. Occasionally, however, a flattened, solid mass of fungus material formed, especially in connection with large cankers. *P. glomeratus* cankers could be readily diagnosed on red maple by making an ax or knife cut into the center of the canker and examining the hard, dark-brown fungus material which was



FIG. 2. Cankers of *Polyporus glomeratus* on red maple. A, canker around branch stub; B, elongated canker; C, multiple cankers on large red maple causing distortion of the trunk.

deposited in and beneath the bark. The rot back of the canker was usually very soft, often with tan-colored mycelial mats filling the rotted areas.

Sporophore formation is similar to that in beech. Fruiting takes place on down logs which have been in contact with the ground for several years. The sporophores are short-lived, especially so in wet weather, and quickly become dark, sodden and insect riddled.

*P. glomeratus* is evidently an important decayer of red maple and on one area of the Gale River Experimental Forest, New Hampshire, fully one-quarter of the trees were cankered or broken because of the rot. The fungus was also common on the Green Mountain National Forest and was noted to a lesser extent on the Tunxis State Forest, Connecticut and in Pennsylvania. J. R. Hansbrough and T. J. Grant have collected *P. glomeratus* on sugar maple (*Acer Saccharum* Marshall) in Maine.

CIVILIAN CONSERVATION CORPS AND  
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# ASCUS DEHISCENCE IN LECANIDION ATRATUM AND ITS SIGNIFICANCE

ELLYS T. BUTLER

(WITH 2 FIGURES)

## INTRODUCTION

Some years ago a taxonomic study of the Patellariaceae was undertaken with the expectation of including comparative culture work to determine the life histories and relationships of these almost totally unknown forms. The Patellariaceae comprise a family of the inoperculate Discomycetes, placed by most authors in the order Pezizales, in spite of the fact that it is admitted certain species are lichenous and many are "lichen parasites" (13). *Lecanidion atratum* (Hedw.) Endl. (*Patellaria atrata* Fries) is the type species of the genus *Patellaria* Fries, for which the family was named (FIG. 1), and is of special interest for its unique method of spore discharge.

The significance of ascus dehiscence in the classification of the Discomycetes has long been an interesting question. Three types of dehiscence are reported for this group; the operculate type, characterized by a circular rupture (ascostome) opening by a lid (operculum), which usually remains attached at one side after spore discharge; the inoperculate type, in which the spores escape at the apex of the ascus through an ascostome which has an elevated or ragged margin, but no definite operculum; and the bilabiate type, in which the opening is a transverse slit at the apex of the ascus (31).

In 1879 Boudier (5) proposed the division of the Discomycetes, on the basis of dehiscence, into two sections—Operculae and Inoperculae, placing those forms having bilabiate dehiscence with the Operculae. His work was overlooked or ignored by some subsequent writers of texts, and those treating the fungi as a whole, who generally followed the old well known systems of classification, but was adopted by all later students of the Disco-

mycetes, who presumably would be better fitted to evaluate his work. Massee (22) thought Boudier's system was impractical, believing the operculum could be observed only in fresh material, but he was mistaken, for these characters may be determined easily in most cases from herbarium material. Boudier (6) himself, after further study and consideration of other characters, was convinced that this method results in the most practical and natural classification of the Discomycetes. Lagarde (21) thought Boudier's system marked important progress in the recognition of natural affinities in this group. His independent studies in comparative anatomy confirmed Boudier's classification and added new arguments in favor of it. Ramsbottom (30) expressed surprise that Boudier's system had not been more generally adopted, and said that these two divisions seemed to have the same importance as the Monocotyledons and Dicotyledons in the Phanerogams. Gäumann and Dodge (14), Gwynne-Vaughn and Barnes (16), and Bessey (4) are among the recent authors of texts who have followed Boudier; and Corner (10), Nannfeldt, and Seaver are outstanding authorities on the Discomycetes who uphold Boudier. Seaver (31, p. 17) maintains that this offers a morphologically sound basis for a natural division of the group. Nannfeldt (25) considers the Discomycetes to be the most primitive forms of his division Ascohymeniales, and divides them into four orders, placing all the operculates in the Pezizales. The remaining three orders contain the inoperculates and most of the discolichens.

#### REVIEW OF THE LITERATURE

Early in the study of the Patellariaceae the writer realized that the thick walled asci of *Lecanidion atratum* were not typical of the inoperculate Discomycetes. Even more interesting was the fact that an ascostome was never observed. Empty asci were frequently noted where the entire upper third of the ascus had broken off (FIG. 2, H-J). The question arose as to whether this breaking off of the upper portion of the ascus, as a thimble-like cap, was the natural method of dehiscence for this species. A search through the literature brought together several different opinions

on this question. Hedwig (17) believed that with the accumulation of water the spores were discharged through the elasticity of the asci. He was uncertain of their subsequent history after they became dry, but thought they were probably dispersed by the wind. His illustration of a vertical section of an apothecium

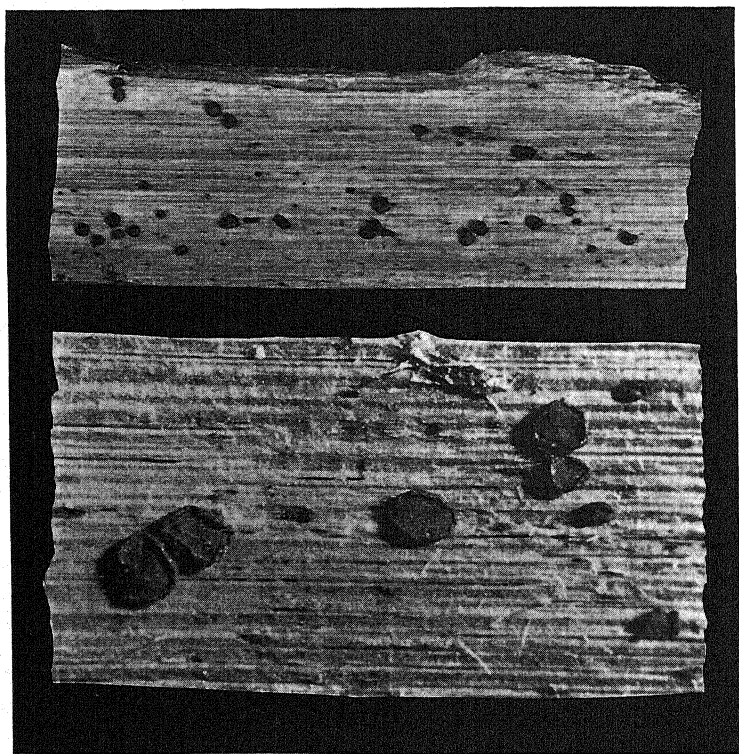


FIG. 1. Upper figure, scattered apothecia of *Lecanidion atratum* on *Agave* stem,  $\times 2$ ; lower figure, apothecia of the same, enlarged  $12\times$ .

shows the heavy epithecium still intact, and numerous spores floating above it.

Nees (26) says that the spores are ejected from the asci when a dry specimen is placed under water. He thought they must be ejected through the lower end of the ascus where it is attached, as he never saw an opening in the upper part. His illustration also shows numerous septate spores above the apothecium.

Crouan and Crouan<sup>1</sup> (11) said that the clavate ascus, when it is about to shed its spores, lengthens, and contracts above forming a beak at its tip. The spores go out through a narrow opening one after the other, and as each spore passes out there is a sort of recoil, which throws it; those which go out last produce so forceful a recoil that the ascus springs back like a cannon after it hurls its projectile. They thought the ring-like constriction near the center of an empty ascus was due to a redoubling of the internal membrane.

Boudier (5, p. 45) criticized these observations of the Crouans saying "... they imperfectly saw another mode of dehiscence in *Lecanidium atrum* (= *Patellaria atrata* Fr.), but they described it badly, for the sporidia, in all the *Pezizae* are discharged at the same time." He later published illustrations that must have been his own idea of spore discharge in this species (7). His figure *i* shows the apex of an empty ascus with an immarginate foramen. Figure *j* he says represents the upper portion of asci after their dehiscence, showing the debris of the membranous sac that envelops the spores and that is often found projecting from and remaining attached to the foramen in the form of a collarete. The writer, as stated before, has never observed an ascostome in *Lecanidion atratum* as illustrated in Boudier's figure *i*. The projecting collarete, shown in his figure *j*, is more understandable although it has never been seen in that form.

#### OBSERVATIONS

A recent collection<sup>2</sup> of this species on weathered *Agave* stems, has made possible the study of ascus dehiscence in living material. These specimens had been air dried and were brought into the laboratory about six weeks after the date of collection. Small

<sup>1</sup> "La thèque est claviforme, on aperçoit quand elle va disséminer ses spores, qu'elle s'étire ou s'allonge en s'atténuant en bec à son sommet, les spores sortent par l'ouverture étroite les unes après les autres et à chaque spore qui sort il y a une espèce de détente qui la lance, celle qui sort la dernière produit une si forte détente que la thèque recule en arrière comme le ferait un canon après avoir lancé son projectile. La thèque étant vide on aperçoit vers son milieu un étranglement ceint par un cercle ou anneau; nous pensons que ce singulier phénomène est dû à un dédoublement de la membrane interne."

<sup>2</sup> Seaver, F. J., Waterston, J. M. and Russell, T. A. Bermuda fungi no.

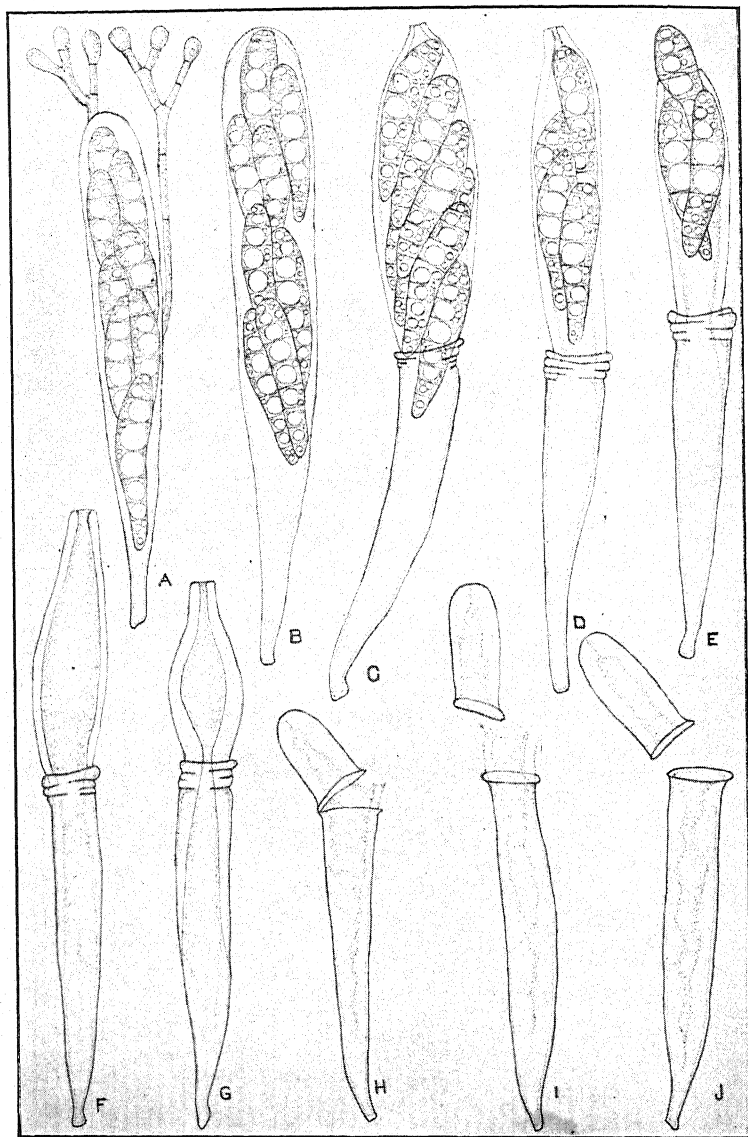


FIG. 2A, paraphyses and ascus of *Lecanidion atratum*; B, elongated ascus immediately before dehiscence; C, ectoascus ruptured at apex and rolled back, endoascus elongating; D, spores discharging from apex of endoascus; E, spore squeezing through opening at apex of endoascus; F, empty ascus immediately after spore discharge; G, empty ascus showing typical swelling of endoascus; H-J, empty asci with thimble-like caps formed when ectoascus breaks below the apex.

blocks of wood bearing mature apothecia were cut out and placed on moistened filter paper in inverted petri dishes containing corn meal agar. The plates were kept at room temperature (about 20° C.) and 12 hours later the surface of the agar, 5 mm. above the apothecia, was found sprinkled with ascospores. Additional spores were discharged from the same apothecia on the four following days. Numerous apothecia were set up in this manner and examined for method of ascus dehiscence during the days of spore discharge. A free hand section of an apothecium was cut and placed on a slide in a drop of water, covered with a cover slip applied with as little pressure as possible, and studied under the microscope. Some asci were injured in sectioning, broken from the hypothecium and floated free in the water, but where the hymenium had been least disturbed and the asci were still attached, spore discharge occurred in the following manner, without the addition of any poisonous stimulant such as Buller used (8). The mature turgid asci were 155-179  $\mu$  long, extending to the tips of the paraphyses, with the spores crowded in the upper two-thirds of the asci, the upper one pressed against the apical wall which was not thickened (FIG. 2B). (Asci measured in this material before it was placed in a moist chamber averaged 115  $\mu$  in length.) The outer ascus wall ruptured at or near the apex and rolled back (FIG. 2C), while at the same time an inner membrane surrounding the spores pushed up above the epithecium. (The term "endoascus" will be used to designate this inner membrane, and the term ectoascus might be applied to the outer wall.) This happened very quickly, the spores being carried up above the ring formed by the outer wall, although two or three spores sometimes remained below this ring. After a few seconds, during which the endoascus continued to lengthen, until it extended above the epithecium nearly one-third the length of the ascus, the spores were shot out successively with considerable force from the apex of the endoascus. The first four spores were shot out in rapid succession, the last ones more slowly, so that the process could be followed easily (FIG. 2D). A spore pushed forward to the apex and, stretching the contracted pore, slowly squeezed through the opening to the point of the maximum width of the spore and then was shot out quickly and forcefully (FIG. 2E). Thus the shape of the spore seems to play an important part in its discharge.

Seaver (31, p. 20) described this process of stretching and contracting in the operculates, but he was unable to follow the discharge closely as there was no pause between spore ejections and the motion was too rapid.

In *Lecanidion atratum* the endoascus recoiled slightly and another spore took its place at the apex, the entire endoascus then lengthened gradually while this spore was slowly pushing through the opening and when nearly the original length was reached the spore was discharged. This continued, the process gradually slowing down, until all the spores had been discharged, although frequently one, more rarely two spores remained within the ascus. The dehiscence of more than 50 asci in water has been watched, and in every case the process was exactly the same as that described above, the only variation being in the time intervals. Usually the spores were discharged immediately after rupture of the outer wall and extension of the endoascus. Sometimes there was a pause after the rupture of the ectoascus and extension of the endoascus, up to three minutes in duration, before the first spore was discharged. Three spores were discharged per second, or there was an interval of two to five seconds between each spore, occasionally an even longer interval in the case of the last spores in the ascus. Immediately following the discharge of the last spore in every case the endoascus shrinks in length and width to one-half or one-third its maximum size, thus withdrawing nearly to the level of the epithecium. It then swells leaving a very narrow opening (FIG. 2G). This may be the collarette of Boudier, but as figure 2G shows, it is not the same in appearance. The Crouans, believing the entire ascus elongated, missed the fact that the beak-like tip was the apex of an inner membrane. The ring-like constriction in the center of the ascus that they mention was probably the broken outer wall, as shown in my figure 2F. Isolated asci also frequently discharge their spores in this manner, although in three unique cases the spores were shot out successively and with force from the torn lower end of the ascus.

#### DISCUSSION

As far as can be determined, this type of spore discharge from an endoascus, characteristic of certain species in the Sphaeriales, Dothideales, and Myriangiiales, has never been reported in the

Discomycetes. In fact, deBary (2) stated it was unlikely that successive ejection would occur in the open hymenia of the Discomycetes. Currey (12) reported and illustrated this type of dehiscence in *Sphaeria herbarum*. Pringsheim (21) was the first to give a detailed account, well illustrated, for *Sphaeria Scirpi* (= *Pleospora scirpicola* (DC.) Karst.) and it is now frequently referred to as the "*Sphaeria Scirpi* method of dehiscence." Sollman (34) illustrated the same type in three other species of *Sphaeria*, *S. inguinans*, *S. ellipsocarpa*, and *S. lanata*; and Woronin (3) in *S. Lemaneae*. It has been reported in the following Sphaeriales: in *Cucurbitaria Laburni* by von Tubeuf (39); in *Ascospora Beijerinckii* by Vuillemin (40); in *Leptosphaeria acuta* by Hodgetts (18); in *Physalospora malorum* by Shear and Stevens (33); in *Ascospora ruborum*; *Mycosphaerella rubina*, and *Venturia inaequalis* by Zeller (41); in *Metasphaeria Asparagi* by Tehon and Stout (38); in *Melanomma* and *Sporormia intermedia* by Ingold (20) who called it "jack-in-the-box" dehiscence; in *Sporormia bipartis* by Page (27), and in certain species of *Pleospora* and in *Pyrenophora* by Atanasoff (1), differing in this case in that the inner wall ruptures not at the apex but just above the ring formed by the contracted outer wall.

Hoggan (19) observed this method of dehiscence in *Plowrightia ribesia* and suggested that it indicates a close relationship between the Dothideales and Sphaeriales.

Various interpretations have been given to the ascus structure in the Myriangiales. Miles (23) considers the ascus in *Myriangium tuberculans* thin walled, but surrounded by the inner sheath of the locule which separates from the stromatic tissue and remains closely attached to the ascus until it ruptures and collapses about the base of the expanding ascus. Stevens and Weedon (36) are uncertain whether *Kusanoopsis guianensis* has the rare condition of an ascus with double walls or merely that the spores protrude, surrounded by a quantity of epiplasm. Tai (37) reports a double wall in the dehiscence of *Myriangium Bambusae*, saying that this character, with others, indicates relationship with the Sphaeriales. It has also been reported in *Myriangium Duriaei* by Millardet (24) and by Petch (28), and in *Myrianginella Tapirae* by Stevens and Weedon (36, p. 199, f. 9).



Ziegenspeck (42) found this type of dehiscence in only one of the lichens, in *Nephroma tomentosum*, a species with open apothecia, classified in the Cyclocarpineae, family Peltigeraceae (35).

In a number of cases it was reported that the outer wall broke below the apex and the thimble-like cap thus formed was pushed up by the expanding inner membrane. This was illustrated for *Sphaeria lanata* (34), *Sphaeria herbarum* (12), *Leptosphaeria acuta* (18), *Sporormia leporina* (9), and used by Griffiths (15) as a basis of classification of *Sporormia*, *Sporormiella*, and *Delitschia*. Hodgetts (18) and Cain (9, p. 12) thought this might be an unnatural mode of dehiscence in some cases, due to artificial pressure. This would seem to be the case in *Lecanidion atratum* where the thimble-like caps were commonly found in crushed mounts, but were never observed in actual ascus dehiscence under more nearly normal conditions. It may be that the outer wall breaks in different places, as has been recorded for some of the Sordariaceae (15, p. 34). When it ruptures below the apex the cap might be carried up by the elongating endoascus, or quickly pushed off.

Nannfeldt has included the above mentioned forms, with the exception of *Nephroma*, in his new group Ascoloculares which he says is characterized by having the asci borne within stromatic bodies with no true perithecial wall and no true paraphyses, and by the *Sphaeria Scirpi* type of dehiscence. In the group Ascohymeniales are genera with thin walled asci, thickened only at the tips, with the exception of the disco-lichens, and certain closely related Discomycetes, namely *Patellaria*, where the ascocarps have a longer life span and the asci are thick walled. Since he believed that they do not have an endoascus type of dehiscence, being provided in every case with an ejaculation mechanism at the apex, he included them in the Ascohymeniales. Nannfeldt placed *Lecanidion* with most of the discolichens in the order Lecanorales, of the Ascohymeniales, distinguished by the usual presence of symbiotic algae, the long lived cartilaginous apothecia, the thick walled asci which stain blue with iodine and the heavy epithecium formed by the paraphyses. He (25, p. 62) pointed out the resemblance of these asci to those of the Ascoloculares and emphasized that they may be distinguished by their positive iodine reaction, and by the pore type of dehiscence. Obviously Nannfeldt had not seen spore

discharge in *Lecanidion*, and probably relied on Boudier's descriptions and illustrations.

Ascus dehiscence is considered a most reliable criterion upon which to base large group relations in the Ascomycetes, as has already been pointed out. Thus the discovery in the Discomycetes of this endoascus type of dehiscence, which was thought to be restricted to certain Pyrenomycetes, or the Ascoloculares according to Nannfeldt, leads to several interesting possibilities. It seems to be an indication of the relationship of *Lecanidion atratum* to those Pyrenomycetes, or the same type of dehiscence may have evolved in several widely separated groups. The Patellariaceae have been considered a connecting link between the Pezizales and Phacidiales and Hysteriales, which in turn lead to the Sphaeriales. One might expect, therefore, a similar method of spore discharge. As Shear (32) has suggested, we may have placed too much emphasis on the importance of the form of fructification in arbitrarily separating Discomycetes from Pyrenomycetes.

As our knowledge of the morphology and life histories of the inoperculate Discomycetes and disco-lichens increases, it will be important for students of these groups to note the mechanism of spore discharge. The endoascus type of dehiscence may be another much needed character to help clarify the relationships of some of these perplexing forms on the border line between the Pyrenomycetes and Discomycetes and lichens, especially in the Patellariaceae, Phacidiaceae and Tryblidiaceae. When this knowledge is correlated with that obtained as the result of other studies, it may be found that our large group of inoperculate Discomycetes naturally falls into two groups, those with an ascostome and those without an ascostome, but with a functional internal membrane.

#### SUMMARY

*Lecanidion atratum*, which has been placed with the inoperculate Discomycetes, has a method of spore discharge unique for that group. The outer ascus wall breaks at, or near the apex and rolls back; an inner membrane, here termed the endoascus, pushes up above the epithecium nearly one-third the length of the ascus; the spores are then shot out successively and forcefully from the apex of the projecting endoascus.

This endoascus type of dehiscence is characteristic of certain Pyrenomycetes, but has not before been reported in any of the Discomycetes. On the basis of this character, which is considered a reliable indicator of relationships, the Patellariaceae seem to show a closer relationship with certain Pyrenomycetes than with the other inoperculate Discomycetes. It may also prove to be an additional criterion of value in determining the natural classification of the inoperculate Discomycetes and disco-lichens.

The writer is greatly indebted to Dr. F. J. Seaver for the collection of living material that made this study possible, and for his generous assistance with the preparation of the manuscript.

NEW YORK BOTANICAL GARDEN

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## A NEW SCLERODERMA FROM BERMUDA

W. C. COKER

(WITH 1 FIGURE)

### *Scleroderma bermudense* sp. nov.

Fructificationes subglobosae, 1.8-2.8 cm. crassae, omnino subterraneae ad maturitatem, undique sparsim delicatis brunneis araneosis fibrillis investitae, ex quibus flocculosae fibrae in solum extendunt, apice in 5 vel 6 lacinias stellatas dehiscentes; peridio siccato 1-1.5 mm. crasso et distincte scissili; peridio humido circa 2-2.5 mm. crasso, praeter fibrillas liberas, ex strato tenuissimo laxo externo circa 0.12-0.18 mm. crasso et strato interno multo fusciori compacto composito.

Sporis brunneis, globosis, echinulato-verruculosis et granulosis, 6-7.5(8)  $\mu$ , paucis per partes reticulatis.

Fruit body subglobose, 1.8-2.8 cm. thick, entirely subterranean until dehiscence, the entire body thinly covered with delicate brown arachnoid fibers which hold fine particles of sandy soil and from which flocculent strands extend into the soil. Dehiscence as in *S. Geaster* but rather more regular than in that species, the lobes usually five or six. Peridium when dry about 1-1.5 mm. thick and distinctly scissile, when soaked about 2-2.5 mm., consisting, in addition to the free fibers, of a very thin, loosely woven paler outer coat about 0.12-0.18 mm. thick and a much darker, dense portion which in thin section shows varying layers of lighter and darker flesh, the innermost layer black.

Spore mass earthy brown (faintly olive), very friable and easily completely shaken out of the peridium; spores brown, globose, minutely spiny-warted and scurfy, 6-7.5(8)  $\mu$ , a few with a partial reticulum; some fibrous fragments mixed with the spores.

Bermuda Islands. In sand, Grape Bay, Nov. 29, 1938, No. 15A. Buried in sand when young, Elbow Beach, Dec. 4, No. 119; Dec. 11, No. 183. All collections by F. J. Seaver and J. M. Waterston.

This *Scleroderma* is nearest *S. Geaster*, from which it easily differs in its delicate attachment to the soil over its entire surface and the absence of any more specialized basal attachment by compacted strands and plates, by its much smaller size, thinner and less tough peridium, and by the ease with which the gleba is

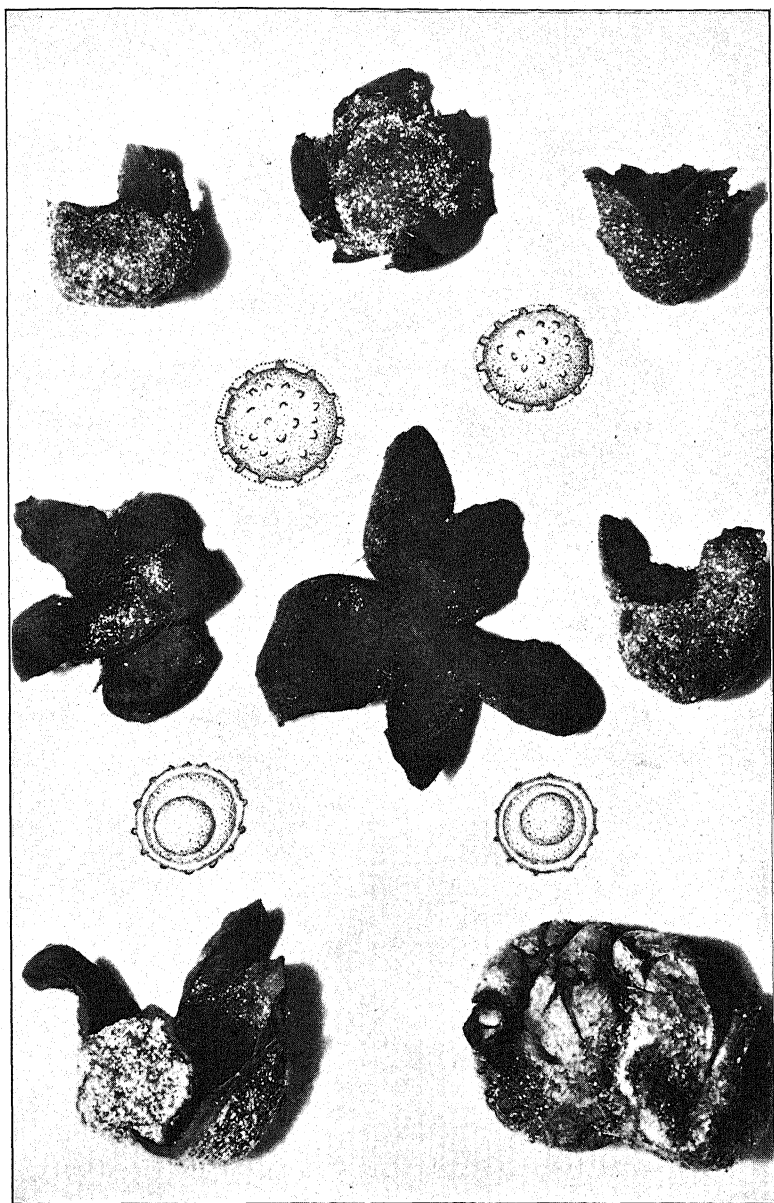


FIG. 1. *Scleroderma bermudense*.

freed from the peridium and can be shaken out as a whole. In most cases the outer coat is dotted all over with small white grains of sand which can be rather easily rubbed off. The spore drawings and the Latin diagnosis are by Miss Alma Holland and the photograph by Miss Laurie Stewart, both of this department.

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CHAPEL HILL, N. C.

#### EXPLANATION OF FIGURE

FIG. 1. *Scleroderma bermudense*. Photographs of fruit bodies in various stages of maturity. In center, remains of old periderm after spores have been dispersed. All photographs natural size. Drawings of four spores in various stages of development  $\times 1000$ .

## NOTES AND BRIEF ARTICLES

### THE PROBLEM OF GAMETE PRODUCTION IN BLASTOCLADIA

I have read with interest and concern the claim made by Dr. Ernst A. Bessey that he has observed isoplanogametes in *Blastocladia Pringsheimii*; and while I do not deny this claim, I wish that it were better substantiated: that he could have observed more than one case of fusion, and that he could have known the source of these "gametes."

*Blastocladia Pringsheimii* Reinsch has been under continuous observation in the grounds and laboratory of Royal Holloway College, University of London, for the past six years. During that time thousands of plants have been examined, and all plants that have ultimately borne resistant sporangia, have previously borne thin-walled sporangia. No plants have been found to bear resistant sporangia only.

From summer 1933 to summer 1935 plants were examined every month (Lloyd 1938), and emission of swarmers from the thin-walled sporangia frequently watched, and never was fusion observed, but instead the swarmers were seen to germinate directly. Miss Lloyd says: "Fields of motile zoospores have been watched to see if zoospores from different sporangia or from sporangia which are borne on different plants show any tendency to fuse. The zoospores vary somewhat in size and some zoospores are less active than others, but from their behaviour there has been no suggestion of a larger female and a smaller male gamete. The flagella of two zoospores have frequently become intertwined; they have, however, always separated later by their own tugging or by the intervention of a third zoospore. Two zoospores have often been seen to come to rest side by side and undergo amoeboid movements, and then one or both have swum away. It is possible that the right combination of gametes (if they are such) has not been obtained, but as many fields of mixed spores have been watched and as germination without fusion has been seen in no less than thirty-two of these it seems unlikely that the zoospores are gametes."



On many occasions since September 1937 quantities of thick-walled resistant sporangia have been germinated (Blackwell 1937) and the swarmers liberated have never been seen to fuse, though many have been watched closely. Instead these swarmers have germinated directly as in the case of swarmers from thin-walled sporangia.

Various thin-skinned berries (of spp. of *Vitis*, *Lycopersicum*, *Solanum*, etc.) have been inoculated with swarmers from resistant sporangia and within two days pustules of fully formed plants of *Blastocladia Pringsheimii* have appeared on the skin. These have borne thin-walled sporangia whose swarmers have been carefully watched and never been seen to fuse, but instead have germinated directly.

During the spring of 1939 Dr. Ralph Emerson applied his delicate and precise technique for isolating swarmers to the material in this laboratory. He isolated zoospores from resistant sporangia and succeeded in germinating them singly in *pure culture* on corn meal agar (Difco). The plants which developed were observed very closely; they bore thin-walled sporangia and liberated swarmers. These swarmers showed no signs of fusion and germinated directly to give new plants like their immediate parent.

While it is admitted that *Blastocladia Pringsheimii* may like *Allomyces Kniepü* (Sörgel 1937) have more than one type of life history and that Dr. Bessey may have a different strain from ours; until the source of the fusing "gametes" is known and more than one instance of fusion observed, the case for isoplanogametes, though possible, can scarcely be said to be proved.—ELIZABETH BLACKWELL.

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L. O. OVERHOLTS, PRESIDENT 1938

# MYCOLOGIA

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## GEOGRAPHICAL DISTRIBUTION OF SOME AMERICAN POLYPORACEAE<sup>1, 2</sup>

L. O. OVERHOLTS

(WITH 30 FIGURES)

Plant Geography is a science of rather recent development. In the literature of this science the titles that deal with the distribution of fungi are few, and fewer yet are those which deal in terms of world wide distribution. The number of species of fungi supposedly known to science at the present time varies with the enumerator from around 60,000 if he is considering the hundreds of known and possible synonyms, to 100,000 if he be merely an enumerator of proposed names. Bisby has surmised that there are possibly 200,000 species of fungi on the earth. Although the number of species reported for North America in Seymour's Host Index is between 40,000 and 50,000 (fide Bisby), the range of the individual species is largely an unknown quantity except in a few groups, and furthermore the records presented in this host index involve only the parasitic fungi and those species of saprophytes that occur on dead plant and animal remains. At any rate the group is large enough to comprise a sizable section of any

<sup>1</sup> Address of the Retiring President of the Mycological Society of America, December 28, 1938, at the Richmond meeting of the American Association for the Advancement of Science.

<sup>2</sup> Authorized for publication on May 16, 1939, as paper no. 905 in the Journal Series of the Pennsylvania Agricultural Experiment Station. Contribution no. 119, Department of Botany, The Pennsylvania State College, State College, Pa.

adequate consideration of the science of plant distribution. Information concerning world wide distribution of fungi must necessarily await the appearance of more or less comprehensive floras enumerating the species of the land areas of the world, and it must be admitted that fewer papers of a monographic nature have appeared for the fungi than for most other groups of comparable size. The distribution of species in the Family Polyporaceae is better known than in most other groups of fungi, and perhaps a beginning could be made in presenting the facts about world distribution of members of this group.

Bisby reports that 60 per cent of the species of fungi known to occur in Manitoba are also present in Europe. He concludes from these and other considerations that in general fungi have a wider distribution than do flowering plants, and cites the point that spores are more easily disseminated than seeds and, therefore, both land and water barriers are less effective in preventing distribution of fungi than they are for seed plants. He mentions other pertinent points in this respect, among which not the least important is the fact that in identifying fungi from the literature, if one finds a fungus which agrees in a few outstanding characters mentioned in the highly inadequate descriptions of most European fungi, he will be inclined to refer the fungus to that species, whereas later investigations may reveal that there are several other points on which there is a total lack of agreement. Therefore, the European name comes into use and it may be many generations before the correct situation is revealed and a more suitable name proposed. Of course, this is offset in part by the fact that no greater a discrepancy than an unreported host or a new geographical location is made the pretext for imposing a new name on the gullible mycological public.

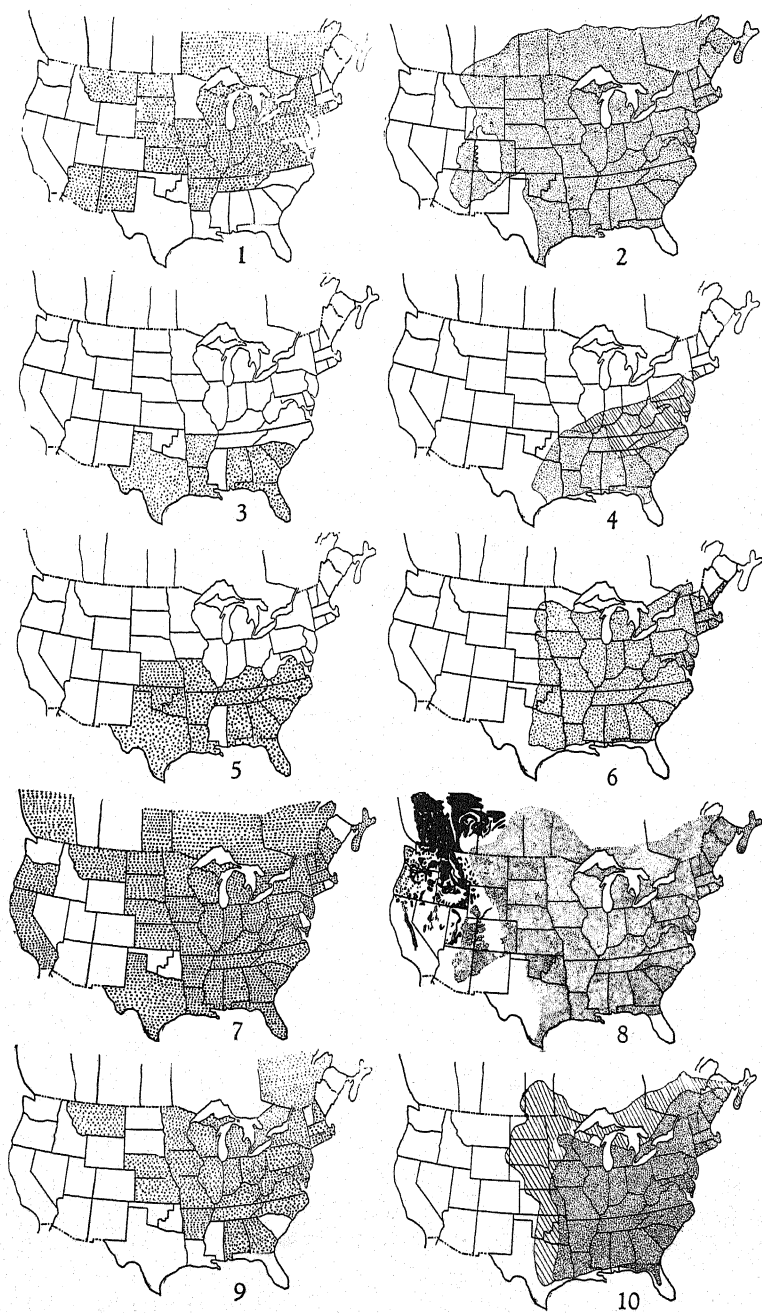
In the Polyporaceae it appears from my own results that at least 43 per cent of the approximately 227 species of American pileate Polyporaceae are known to occur in Europe or in other parts of the eastern hemisphere. Breaking the group down into genera we find that 54 per cent of the species of *Fomes*, 50 per cent of *Daedalea*, 54 per cent of *Trametes*, 50 per cent of *Lenzites*, and 44 per cent of *Polyporus* species of the United States and Canada are represented in non-American floras.

That many species of fungi have a wide distribution, cannot be doubted; yet, only in a few groups are generalizations made now likely to be upheld by future investigations. However this may be, a lack of uniformity in nomenclature, variations in interpretation of species concepts, and the added confusion introduced by the phenomenon of parasitism (together with the restrictions mentioned above) would still render hazardous any attempts at discussing the group from the viewpoint of world distribution.

In the preparation of a manuscript for a monographic treatise of the pileate polypores of the United States and Canada, I have resorted to a series of mapped distributions of individual species. It is only by use of aids of this sort that one secures, in the shortest interval of time, an adequate idea of the distribution of a species. An extensive list of states in which a species is known to occur must be scrutinized carefully in order to build up an adequate mental image of the details of geographical distribution. It is in connection with these distribution maps that I want to call attention to certain features of distribution of North American Polyporaceae in North America.

First, however, we must consider some of the factors that determine distributions in such a group of fungi as the polypores. It must be recalled, for example, that some of the species are terrestrial; others grow on dead wood; and still others grow on living trees. As to the terrestrial species of polypores, the factors that govern their distribution, though perhaps in the main known, have never been evaluated. As one studies distributional maps of such species it becomes clear that climatic factors must be important in this group. Of these factors undoubtedly temperature and moisture must be the predominating ones, although it is possible that light must not be disregarded and in all probability the distribution of some is influenced by the character of the surrounding vegetation which in turn influences the composition of the forest duff and the upper soil layers. For this particular group of polypores it seems to me that the factors that control distribution must primarily reside in about the same group of factors that is said to be of most importance in the distribution of phanerogams.

For the second and third groups above enumerated, *i.e.*, those growing on wood, including living trees, it is just as certain that



FIGS. 1-10.

the distribution of hosts and substrata must be of primary importance. That they are not the only factors involved is shown in a number of instances where the distribution of the fungus is not coextensive with that of the substrata. Thus *Juniperus virginiana* has a distributional range roughly from southern Maine to northern Florida and westward to eastern North Dakota and eastern Texas (FIG. 6). Yet *Polyporus pinsitus*, largely confined to this host but also occurring on a number of others with an even greater northern and western range, is known only from Virginia to Nebraska and southward (FIG. 5). It seems to me quite likely that temperature is the controlling factor in this instance, especially since the fungus extends to the western limits of its major host range but falls some 500 miles short of reaching the northern limits of that range. Another instance is that of *Daedalea quercina* which occurs principally on *Castanea dentata* and various species of *Quercus*, including *Q. alba*, but is known also on *Fagus grandifolia*, *Fraxinus americana*, *Juglans nigra*, *Ulmus americana*, and a few others. Except for Iowa, the present known distribution of the fungus is from Maine to North Carolina and west to New York and Ohio, while *Q. alba* ranges westward and northward to Wisconsin and Minnesota, and south to Florida and the Gulf States. The other hosts enumerated either are included in this range or extend only slightly beyond it. It may be questionable what the controlling factor is in this case, but it is definitely not host distribution. Other similar cases could be cited.

On the other hand, there are numerous cases where fungus and known hosts are almost identically distributed as would be expected if host range is the only determinant of distribution. Such a case is that of *Polyporus conchifer*, a species all but restricted to *Ulmus americana*. The range of the host in its native condition is across the eastern United States and southern Canada to Manitoba and Texas. The fungus actually surpasses the limits of this distribution in Montana (reported by Weir, perhaps on planted specimens of the elm), and is known to occur from Ottawa, Canada, to the Gulf states and west to Nebraska. Here again instances could be multiplied.

I have now indicated that there are cases in which climatic factors seem to govern distribution, and other cases in which the



range of the host is the only operative factor, sometimes with temperature as a secondary factor and sometimes without its effects being manifest. It might be pointed out, however, that in some cases where the fungus distribution seems to be controlled by the distribution of the host, it is after all temperature working through its effect on host that is actually the controlling factor.

In studying distributional maps of the polypores the idea occurred to me that in a group like this where there is considerable information as to distribution, yet a group in which much more remains to be learned on the subject, it ought to be possible to predict with some degree of success the eventual distributions of the species as they will be worked out in time.

Perhaps it may sound presumptuous when I say that I believe that after one spends the major portion of a lifetime in close contact with a rather small group of fungi, one gets an insight into the idiosyncrasies of the species that is not obtainable in the short span of, let us say, one's graduate study days. I believe that one gets a "feel" for the species that will often enable him to predict the behavior of these species under a given set of conditions. Everyone will agree that after handling a multiplicity of specimens, representing all degrees of development, undevelopment, and even decay, one attains a facility in the recognition of these species in their various guises that cannot be otherwise obtained. If such is possible in the field of identification, why is it not possible to develop such an understanding attitude that one can predict distribution?

Nor do I mean to say that the thought is entirely a new one. Undoubtedly every taxonomist has had to admit that after all a given extension to a geographical range is not so surprising when the known facts of distribution and host range are considered. At the same time, host distribution often accounts for the presence of a fungus in one state and its absence from an adjacent state, when one knowing only of its presence in the former instance is surprised to find it absent in the latter. Thus one can predict with some degree of assurance that *Polyporus amarus*, though occurring in California and Oregon, will not be found in Nevada nor in Washington, since its host is *Libocedrus decurrens*. In some cases one must take into account the fact that many species of

forest trees are planted more or less extensively in areas outside of their native range. Thus, while one is surprised to find *Polyporus conchifer* reported from Montana on *Ulmus americana*, yet when one considers that that tree species is widely planted in the United States, the report is at least credible.

That there are pitfalls in such a procedure is undeniable. The fact just mentioned concerning man's attempts at extending the range of host plants is one of them, and this might lead to the establishment of a species of fungus at long distances from its previously known range. Another is the question as to the authenticity of our records of host distribution. I have relied mainly for this information on a recently published series of distribution maps by E. N. Munn, of the United States Forest Service, published as U. S. Department Agriculture, Miscellaneous Publication no. 287, 1938. Some information I have secured from Sargent's Manual of the Trees of North America, of less use to me, however, because it does not give mapped distributions. Munn's distribution of *Ulmus americana*, for example, shows that the western limit of its range contacts but does not cross the eastern borders of Wyoming and Montana. Perhaps this may not be taken to indicate the entire absence of this species in either of those states. There may also be a question as to whether all of our fungus species (or even host species) have actually reached the limits of their ranges. Perhaps some of them have in comparatively recent times been introduced from other lands and have not yet had time to disseminate themselves as widely as will eventually occur. Particularly might this occur to a fungus species which found in its new environment a hitherto unused host capable of sustaining it. Predictions as to final distributional range might easily be wrecked in such an instance. Finally, one's ideas as to species limits may be shown to be too narrow or too broad in some cases which could not be matters of opinion.

In the making of the maps to illustrate the fungus distributions that I shall now discuss, I have had the advantage of having access to the leading herbaria of the eastern United States over a period of more than a score of years. I have received thousands of specimens from correspondents scattered over the United States and Canada. And finally I have myself collected extensively over the

area except the far West. In addition to this I have accepted the printed records of those whom I judge to have been competent namers of collections as such records have appeared in the literature. Obviously the early lists contain too many errors and discrepancies to be of much value. That all the records used in making the maps are without error is too much to hope. I shall illustrate this point with a single example. The species involved is *Daedalea ambigua*. According to my own records this species should not occur north of southern Ohio, Indiana and Illinois. Hence a recently reported record from "New Berne" New York looked suspicious, especially since no such locality could be found on any map nor in the U. S. Postal Guide. A letter to Dr. House at Albany, to whom the collection was credited, brought the information that the specimen was collected at New Berne, *North Carolina*. At the same time it had been noticed that Miss Wolf reported the same species from Iowa. A perusal of her paper shows, however, that she was including it only on the basis of an earlier report by Dr. MacBride, and she states that no specimen exists so far as she is aware. Hence I have excluded the state of Iowa from the known distribution of this species. This emboldens me to view with suspicion another northern record of the same species from Algoma, Wisconsin. Either of these last two might conceivably be true, but the facts of the distribution of the species based on specimens that I have examined argues against both of these records.

The maps as prepared have an additional flaw. In some cases a state is included on the basis of a single specimen; the map as presented, however, would seem to indicate the presence of the species throughout that state. Such an inference is not intended, but until more records for each state are available the distribution could scarcely be mapped more accurately. States which show a wide diversity of climate in different areas, or a wide diversity of topography, or a localization of host ranges within its borders are the ones, of course, in which one may expect discrepancies in fungous distributions. For example, many species are reported from the mountainous sections of Colorado that certainly do not occur in the high plateau region of the eastern part of the state. These differences are not reflected in the maps and it would appear

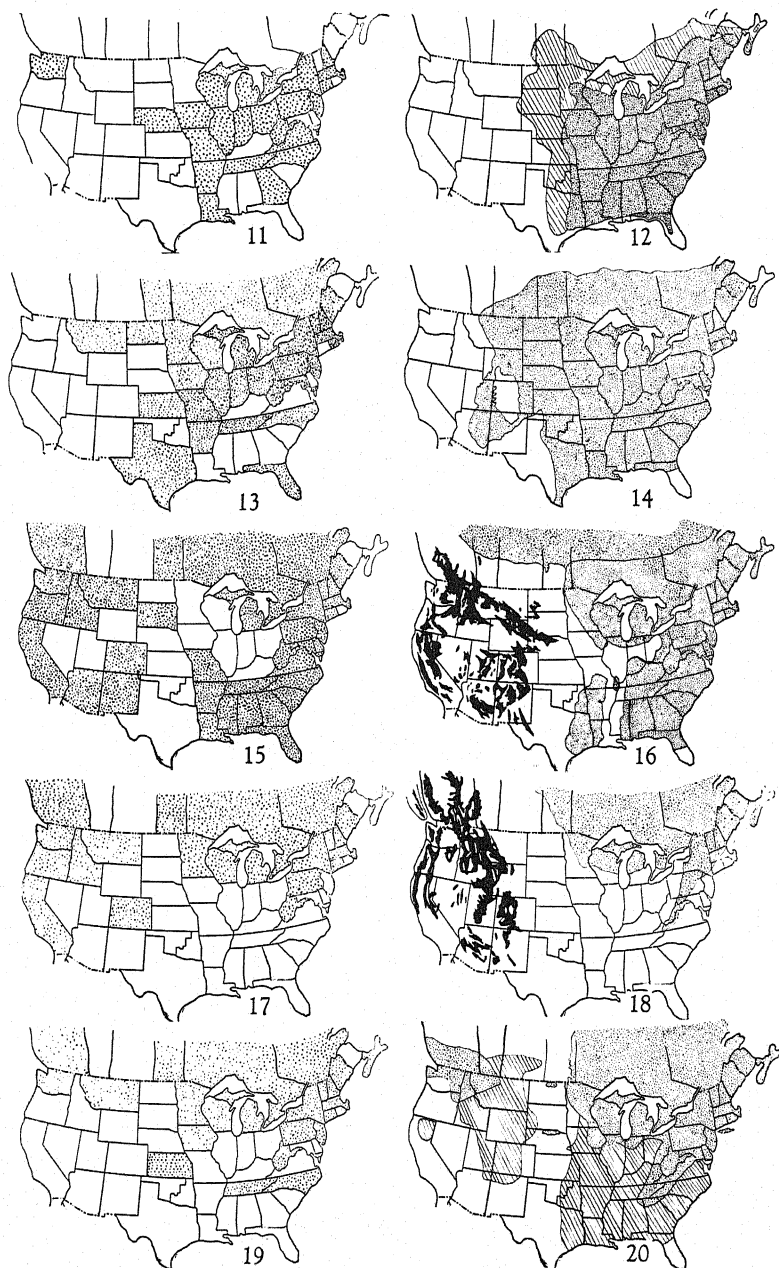
from them that the species occurs through the state. Species reported commonly from northern California may not occur in southern California at all; again this is not taken care of. To have limited the mapped distribution to those stations from which specimens have been examined or reported would be going to the opposite extreme.

It is, of course, not feasible to include in this paper all of the 200 species of polypores occurring in the United States and Canada. Actually only a few are considered and they are all wood-inhabiting species. Only enough species are included to indicate the feasibility of prognostications of this sort. Nor is the subject presented without the hope that yet another result may accrue. Many states are little known mycologically. For example, though the fungous flora of Rhode Island must be essentially the same as that of Massachusetts and Connecticut, yet the reader will note from the maps that no eastern state is so poorly represented in the distributions as is that one. Specimens from that state are not found in any number in any of the main herbaria of the East. Oklahoma fungi are likewise poorly represented in the larger herbaria as are also those of Arizona, New Mexico, Utah, and Nevada. I have not yet succeeded in obtaining a record of the occurrence of any species in every state of the Union. The closest approach is in the species *Polyporus adustus* for which specimens have been examined from every state except Utah and Nevada, and from all the Canadian Provinces except Saskatchewan. I have seen specimens or have what I consider to be authentic records of *Lenzites saepiaria* from all of the states except Rhode Island, Delaware, Oklahoma and Nevada. *P. versicolor* is lacking representation in Rhode Island, New Hampshire, Wyoming, Utah and Nevada, though I do not doubt that I have myself seen the species growing in both of the former states. *P. pargamensis* is represented in all but Nebraska, Arizona, and California. There is not the slightest doubt that each of these species occurs in every state in the union and every Canadian province. Is it too much to hope that as a result of calling attention to these and other unwarranted gaps in distribution that additional distributions may be secured? If every mycologist who is fortunate enough to spend time in any of the states from which no list of polypores has been presented

would collect even the most common species and send them to one of the larger eastern herbaria he or she would be making a definite contribution to our knowledge of the distribution of the species of this group. By way of illustration, I might add that in a small random lot of about a dozen collections picked up recently at my request by a non-mycological botanist of Oklahoma, six new records for that state were secured.

The optimum temperatures for growth of these fungi in pure culture, so far as determined at the present time, have been of no assistance in these prognostications. For example, the optimum temperature for *Fomes Pini* is given as 20° C., and for *Lenzites saepiaria* as 36° C., the former classed by Humphrey and Siggers as a low-temperature organism and the latter as a high-temperature organism. These facts are not reflected in the distribution of the species. Both occur from Canada to Florida and both will eventually be known from every state in the Union and from all of the Canadian provinces. Likewise *Daedalea ambigua* and *Lenzites Berkeleyi* are classed in the intermediate temperature group by Humphrey and Siggers. Yet both are southern in distribution, the latter being practically confined to the Gulf States. Moreover it is easily conceivable that two fungi as different in their optima as *Fomes Pini* (20° C.) and *Lenzites saepiaria* (36° C.), one inhabiting living trees and the other on dead and down timber in exposed situations, might both be growing at their optima though separated from each other by distances of but a few feet and hence exposed to the same climatic factors of the atmosphere. After all it is the conditions that exist within the substratum that must be in the main the determining factors. For example, regardless of the air temperature, the temperature within an old log or piece of slash might approach the optimum for the latter species while the temperature within the living tree might be just as close to the optimum for the former. And even further, it may well be that factors inherent in the substrate itself may shift the optima. After all, the optima as determined by the growth of fungi in pure culture are for those fungi growing under a definite set of conditions that may fall far short of representing the conditions under which the fungus naturally grows.

Space does not permit the incorporation of maps of several spe-



FIGS. 11-20.

cies on which predictions were made in the preparation of this paper. Hence, about a third of the species discussed are without distributional maps of both fungus and hosts.

With the preceding considerations in view we may now proceed with some predictions concerning distribution of species. The procedure is simple. The distribution of a given species as known at the present time is mapped. From among the species of trees which are known to give suitable substrates for this fungus, there is selected one or more species whose combined ranges overrun (if possible) the known range of the fungus. The two maps are then compared. Reference to the maps representative of *Fomes fraxinophilus* (FIGS. 1, 2) may make this clear. All of these maps are presented in pairs, figures 1 and 2 representing one species, 3 and 4 another species, etc. The range map for the fungus is in each case on the left, the host range map on the right. By comparing figures 1 and 2 conclusions are drawn as follows: (1) the fungus is undoubtedly present in Minnesota; (2) it should eventually be found in New Jersey, Delaware and Maryland; (3) since it is recorded from Quebec and from New York and Connecticut it will also eventually be found in all of the New England states and in New Brunswick and Nova Scotia, although its rarity in Pennsylvania, New York and Quebec as compared with its abundance in the middle-west indicates that it may require considerable search before it is located in any of those regions; (4) to the south its general absence so far from the Gulf states indicates that little can be expected from that region although suitable hosts are not lacking. In other words, the fungus is probably temperature-limited to some extent and this may be the factor operative in both the New England and the Gulf states region; (5) to the westward it should eventually be found in Oklahoma, Colorado and Wyoming and also farther north in Manitoba. The center of distribution of this fungus being in the upper Mississippi and Ohio River valleys, it is not likely that in any of the outlying regions mentioned it will prove to be at all common.

#### DAEDALEA AMBIGUA

This species is at present known to occur from Ohio and Illinois south to the Gulf of Mexico. It occurs on a variety of hosts in-

cluding *Diospyros*, *Celtis*, *Quercus*, *Ulmus*, *Acer* and others. Its present range corresponds roughly to the range of *Diospyros virginiana*, which is one of its more frequent hosts. All of its other hosts overrun this range. The fungus will, of course, be found in Kentucky, Virginia, Maryland and Delaware. In addition to these states I do not believe its range will ever exceed that now known except possibly for southeastern Pennsylvania and southeastern Nebraska. Hence, although the hosts on which it occurs extend considerably beyond its known range it is probably again a species limited by some climatic factor, of which temperature is the most likely.

#### FOMES CONCHATUS

Consideration of the known distribution of the fungus (FIG. 13) and of its *Fraxinus* hosts (FIG. 14) indicates that the fungus will most certainly be found in New Brunswick, Nova Scotia, Connecticut, Delaware, Virginia, Kentucky, Oklahoma, Nebraska, South Dakota, Alberta and Saskatchewan, and possibly in South Carolina, Georgia, Alabama, Mississippi, Louisiana, New Mexico, Arizona, Colorado, Utah and Wyoming. This assumes that Lloyd's record of the species from Florida is correct. Otherwise the fungus may be somewhat temperature limited in the southeast. The fact that the fungus is known on nearly 20 genera of hardwoods besides *Fraxinus*, is additional evidence of its wide range. The fact that it has never been collected in Colorado may indicate that it may be rare westward.

#### FOMES EVERHARTII

*F. Everhartii* occurs generally over the eastern half of the United States (FIG. 9). Its hosts comprise most of the species of *Quercus* and in addition a variety of common hardwoods of other genera, including *Carya*, *Fagus*, *Juglans*, *Liriodendron*, and *Ulmus*, but these last named hosts are only occasionally used. The distribution of its combined *Quercus* hosts is shown in figure 10. Few of the other hardwoods which it uses surpass the range of the *Quercus* hosts, and since it does not cover the range of the latter hosts the others can be of little importance. Considering these facts, I expect it to eventually be collected in Vermont, South Carolina, Mis-



Mississippi, Oklahoma, North and South Dakota, and in Quebec. If *Fomes dependens* and *F. praerimosus* be considered forms of this species, the range will be extended to Florida, Texas, New Mexico, and Arizona and possibly Utah and Colorado.

#### FOMES FRAXINEUS

This is a rare species known from about nine states from New York to Florida and Louisiana. It occurs usually on species of *Fraxinus*, on *Acer Negundo*, on *Nyssa sylvatica* and on *Ulmus*, but nowhere outside the distribution of *Fraxinus americana*. The fungus should eventually be found in lower Ontario and from all of the states east of the Mississippi River.

#### FOMES FRAXINOPHILUS

The center of distribution of this fungus is in the Mississippi and Ohio River valleys. Outside of this area it is rare, but is known to occur (FIG. 1) from Quebec to Virginia and west to Montana and Arizona. This does not include the distribution of *F. Ellisianus* which is sometimes regarded as a variety. The species is found almost exclusively on *Fraxinus* but has been reported on *Platanus*, *Quercus*, *Ulmus* and *Salix*. The range of acceptable hosts is shown in figure 2. I believe the fungus is to an extent temperature limited since it has been found in none of the Gulf states. It should occur through the northeastern section of the country and will be found in New Jersey, Delaware, Maryland, North Carolina, Oklahoma, Colorado, Wyoming, Minnesota and in Manitoba.

#### FOMES PINI

Although this is usually described as a cosmopolitan species in the northern hemisphere, there are no exact records of its distribution in the United States. The map for the species (FIG. 21) shows that there are records of its occurrence generally throughout the United States and Canada. Figure 22 shows that its hosts are present in every state in the Union except Kansas, and Bartholomew's list includes the fungus from that state though he does not name the host. There can be no question but that the species occurs in every state and province.

## FOMES FULVUS

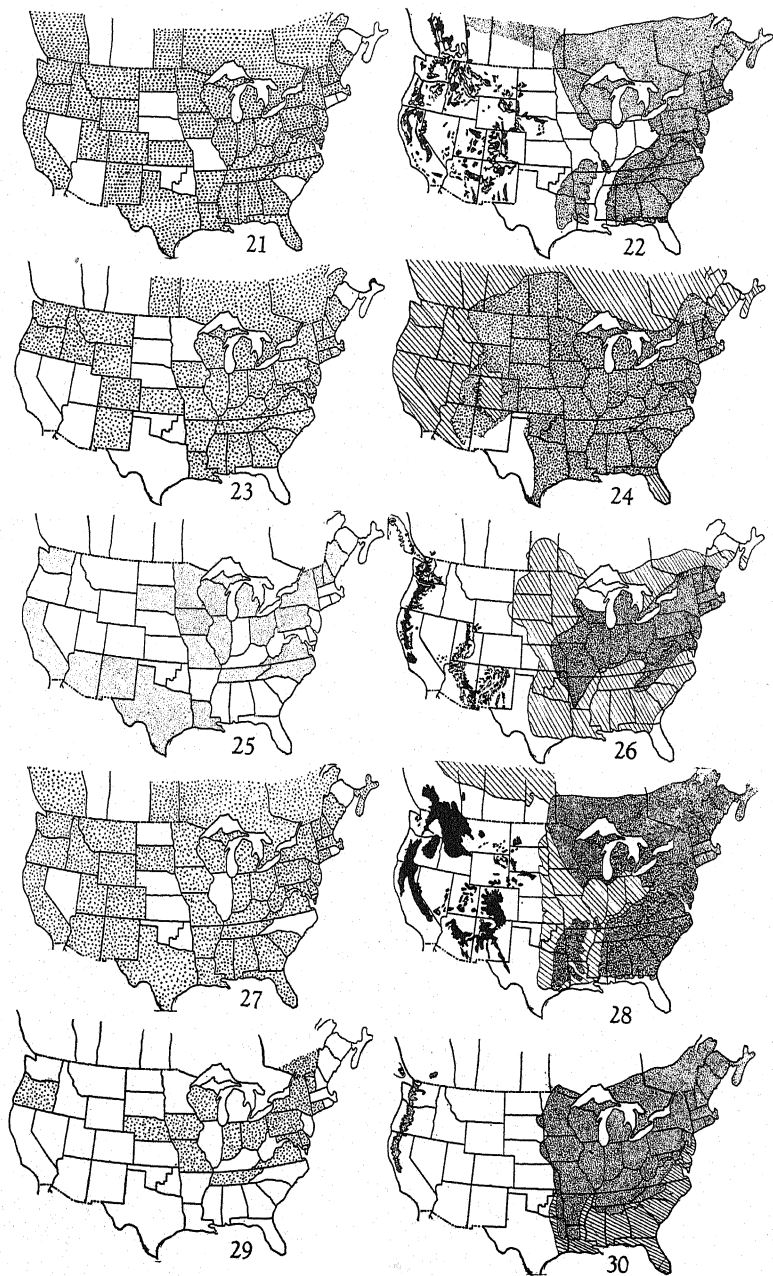
The known distribution of this fungus is a bit irregular but it appears to be well scattered over the country east of the Rocky Mountains. It is not a common species, except perhaps locally. The matter of its hosts has not been accurately determined. It is practically confined to the wild plum species of the genus *Prunus*, being reported mainly on *P. americana* and *P. nigra*, which together account for the known range of the fungus. From its range map one could predict with considerable confidence that the final distribution of the fungus will include also Quebec, Vermont, New Hampshire, New York, New Jersey, Delaware, Florida, Mississippi, Louisiana, Texas, Arkansas, Oklahoma, Illinois, Wisconsin, South Dakota, and Wyoming.

## LENZITES BETULINA

This is one of the more widespread of the species of polypores (FIG. 7). It occurs on more than 20 genera of hardwoods, and is known from practically the whole of the United States except in the western mountains from Idaho to New Mexico. Figure 8 is sufficient to show that among its hosts are species known from every state in the union and from all of the Canadian provinces. *Fraxinus pennsylvanica lanceolata*, *Prunus serotina*, and *Populus tremuloides* are such hosts. Nevertheless the fungus must be extremely rare in that area from which it is not yet known, since Shope does not report it in his extensive studies of Colorado Polyporaceae, and neither Kauffman nor myself found it in extensive collecting in the same state. Nevertheless I predict that it will eventually be found in every state in the Union and in all of the Canadian provinces. In the East, only Delaware, Rhode Island, and New Brunswick are without records of it, but, of course, these gaps will eventually be filled. In northern Ontario and Quebec the host is usually a species of *Betula* and on the west coast *Quercus* more frequently serves.

## POLYPORUS ABIETINUS

*Polyporus abietinus* is one of the most widespread and abundant species of all of the polypores. Its known distribution is shown



FIGS. 21-30.

in figure 27. It inhabits all species of conifers. Since there are one or more species of conifers in every state in the Union (FIG. 28), and since it seems to have little in the way of climatic inhibitions, there can be little doubt that the remaining states of Rhode Island and North Carolina (in both of which I have undoubtedly seen it growing myself), Illinois, Oklahoma, Kansas, Nebraska, North Dakota, and Nevada will eventually produce it as will New Brunswick, Alberta and Saskatchewan.

#### POLYPORUS AMARUS

*P. amarus* is the fungus causing the defect in *Libocedrus decurrens* known as "pin rot." It is practically confined to that host, but at the Brooklyn Botanic Garden there is a specimen collected by Hubert on *Abies grandis* in Idaho. Except for the Idaho station the distributions of host and fungus agree, and if the fungus were at all common on *Abies grandis* or any other western conifer this fact would have been discovered in the extensive work done on timber decay fungi in that region, for though sporophores are seldom collected, due to their early succumbing to the ravages of beetles, yet the rot is highly characteristic and easily recognized. Boyce reports a similar decay in western red cedar but states that it is not known to be caused by this fungus. Hence, I conclude that the general range of the fungus is now known. It is to be regarded as a host-limited species though its local distribution may possibly be governed by other factors.

#### POLYPORUS BALSAMEUS

*P. balsameus* is a species limited both in geographical range and in its host species. The species is confined to the cooler regions of the northeast, ranging south in the mountains to Tennessee and North Carolina. The map showing the distribution of *Abies balsamea*, its chief host, is almost of identical outline with the known distribution of the fungus. Its chief minor host is *Tsuga canadensis*. The fungus should eventually be found in New Brunswick, Maine, New Hampshire, Vermont, western Massachusetts, Maryland, West Virginia, eastern Kentucky and in Manitoba. It probably will also be found in the balsam fir region of Saskatchewan, Alberta and British Columbia.

## POLYPORUS BETULINUS

*P. betulinus* is a rather widespread species in the northern United States and Canada but with a rather discontinuous distribution (FIG. 19). It occurs only on species of *Betula*, especially *Betula papyrifera*, *B. populifolia*, *B. lenta*, and *B. lutea* in that order of frequency in the east and on *B. papyrifera* var. *occidentalis* in Montana. It has not been reported on *B. fontinalis* which ranges southward in the Rocky Mountains to Arizona and New Mexico, nor on *B. nigra*. Since within the range of this species and the variety mentioned rather intensive collecting has failed to produce it, I conclude that it will not be found in southern states where *B. nigra* overruns the limits of its more acceptable hosts nor in the west in that region where *B. fontinalis* exceeds the range of known acceptable hosts. It is undoubtedly present in New Brunswick, Rhode Island, Delaware and Maryland, and probably also in Virginia, Kentucky, northern Illinois and Indiana, and possibly in Ohio, Idaho, and Alberta. Bartholomew reports it from Kansas and so far as I can find, *Betula nigra* is the only host native to that state, although possibly *B. papyrifera* or one of its varieties may be planted extensively. As a matter of fact, the Kansas record does not sound plausible.

## POLYPORUS CINNABARINUS

Although this species is usually regarded as universal in distribution in the northern hemisphere where any hardwood substrata at all are present, there appear to be 11 states from which it has not been reported (FIG. 24). And though these are somewhat grouped, it indicates undoubtedly a lessened population rather than a total absence of the species, especially since the fungus does occasionally occur on coniferous wood. As shown in the map (FIG. 25) it takes the combined distributions of but two substratal species, *Fraxinus pennsylvanica lanceolata* and *Populus tremuloides*, to cover the entire range of the United States and Canada. There is no reason to suppose, therefore, but that *P. cinnabarinus* occurs in every state in the Union and every province in Canada. If more evidence as to the possibility of its occurrence in the arid southwest were desired it might be pointed out that it is distinctly a xerophytic type of fungus and is already known from New Mexico.

## POLYPORUS CONCHIFER

*P. conchifer*, although reported a number of times on hosts other than *Ulmus americana*, is nevertheless practically confined to that species of host. Although perhaps less common southward the fungus has been widely reported from North Dakota and Kansas eastward—a range that is covered almost in its entirety by the range of the host. Moreover the host is widely planted for shade and ornamental purposes. This may account for Weir's report of the fungus from Montana, since distribution maps do not indicate the presence of the host in that state. There can be little question that the fungus will eventually be reported from New Brunswick, Nova Scotia, North Carolina, South Carolina, Florida, Mississippi, Louisiana, Texas, Oklahoma, and South Dakota, *i.e.*, the fungus will eventually be known from the entire range of the host and possibly from some states where the host is not native but is widely planted.

## POLYPORUS CROCEUS

*P. croceus* is known from New York to Florida and west to Minnesota and Arkansas. Its hosts are *Castanea dentata* and various species of *Quercus*. The host range of *Quercus alba* nicely covers the range of the fungus as at present known. Both on the north and the west acceptable hosts overrun the range of *Q. alba* but I predict that the range of the fungus will not be extended to cover much of this host range. It will, however, be finally reported from New Jersey, Maryland, Georgia, Alabama, Mississippi, and Louisiana, and probably in eastern Oklahoma and Texas; probably also in southern Ontario.

## POLYPORUS DELECTANS

*P. delectans* occurs on half a dozen hardwood genera, more commonly on *Acer* than others which include *Carya*, *Fraxinus*, *Juglans*, *Populus* and *Quercus*. The known range of the fungus is shown in figure 29, mainly eastern but quite scattered. The range of *Acer Saccharum* covers the fungus range. Other acceptable species of host occur on the south (FIG. 30). The fungus is considered to be temperature-limited, however, since it does not reach the southern limits of its main host (*A. Saccharum*). The fungus should yet

be found in New Brunswick, Nova Scotia, Maine, New Hampshire, Massachusetts, Rhode Island, New Jersey, West Virginia, Kentucky, Illinois, Michigan, and Minnesota; possibly in North Dakota, South Dakota, Kansas and Arkansas.

In the west it is known to occur on *Quercus*, probably *Q. Garryana*. It should occur also on that host in Washington and perhaps California.

#### POLYPORUS DRYOPHILUS

Few species have as wide a range as this. It is known throughout the United States except in the Gulf States and the Central West (FIG. 25). It has not been recorded from Canada. Its hosts are various species of oaks and in addition it has been collected on species of *Acer*, *Fagus*, *Prunus*, and *Schinus*. There is a variety on *Populus* which is not here included. The combined range of but a few of its hosts would cover the known range of the fungus in the states as far west as the Dakotas (FIG. 26). Various species of *Quercus* are found in practically all parts of the United States and in eastern Canada. Idaho and Montana seem to be states outside the range of oaks—hence the fungus can hardly be expected there. The fact that it has not yet been reported from Canada indicates that not much can be expected from that region in the future, although it probably will be found in lower Ontario and Quebec. Otherwise it should eventually be collected in Massachusetts, Connecticut, Rhode Island, New Jersey, Delaware, West Virginia, Maryland, Kentucky, Indiana, Arkansas, Mississippi, Oklahoma, North Dakota and Utah. The var. *vulpinus* is already known from Quebec and Ontario.

#### POLYPORUS FIBRILLOSUS

*P. fibrillosus* is rather widely distributed (FIG. 17) in the northern states and Canada on *Abies*, *Picea*, *Larix*, *Tsuga* and *Pseudotsuga*. In the east its range corresponds almost exactly to that of *Abies balsamea* and in the west the range of *Pseudotsuga* overruns the range of the fungus (FIG. 18). From a consideration of these maps I predict that the fungus will eventually be found also in Nova Scotia, New Brunswick, Nevada, Utah, Wyoming, Alberta, and Saskatchewan, and possibly in the high mountains of western

Virginia, western North Carolina, and eastern Tennessee. Since there are also acceptable pine substrata in North Dakota and South Dakota, it will also likely be found in those states.

#### POLYPORUS GUTTULATUS

This is a characteristic species of the northern and cooler coniferous forests, widely distributed except in the south and in the western plains country. In the east its range is practically that of the combined ranges of *Abies balsamea* and *Tsuga canadensis* which are favorite hosts, though the fungus occurs also on species of five other genera of conifers and occasionally on hardwoods. In the east it should yet be found in New Brunswick, Nova Scotia, Connecticut, Rhode Island, New Jersey, Maryland and West Virginia. In the west its range approximates that of *Pseudotsuga taxifolia* and it should yet be found in Alberta, northern Saskatchewan, Montana, Wyoming, Colorado, Nevada and Utah; possibly in Arizona and New Mexico.

#### POLYPORUS LUDOVICIANUS

This is a southern species. The known range outside of the Gulf States (FIG. 3) includes only Arkansas, Georgia and South Carolina. It occurs on various species of *Quercus* and perhaps even more commonly on *Liquidambar styraciflua*. Its range as known at present corresponds closely to the range of *Q. nigra* (FIG. 4) on which it occurs. The limits of other species of *Quercus* and of *Liquidambar styraciflua* overlap that of *Q. nigra* and extend northward and (in case of some of the oaks) westward. Yet except for Mississippi and possibly eastern Oklahoma, I predict that the range of the fungus will not be extended by future collectors. It is apparently a species that is limited by temperature.

#### POLYPORUS PINSITUS

Reference has already been made to this species as one whose known range falls considerably short of equalling the range of its usual host, *Juniperus virginiana*. That the distribution shown on the map (FIG. 5) is approximately correct for its actual range is indicated by the fact that the only gap in the range over which it



has been collected is the state of Mississippi. The indications are, therefore, that some factor other than host range (FIG. 6) is limiting the range of the fungus. I take this factor to be in all probability concerned with temperature. I would consider, therefore, the state of Mississippi as the only certain addition to the list of states, with the hint that southern Illinois and southern Indiana would be worthy of further exploration in its behalf. A number of southern species extend their range up the Mississippi River Valley. To the west it is possible that it may yet be found in New Mexico and Arizona since it has been collected on *Prosopis* in Texas at the edge of the range of *Juniperus*, and *Prosopis* ranges even farther westward.

#### POLYPORUS SCHWEINITZII

Here again we have a species of wide distribution, already known from all of the principal conifer regions of the United States and Canada (FIG. 15). In other words, it appears to have no pronounced climatic limitations. It appears to attack all genera of coniferous trees except *Juniperus* and, therefore, finds suitable substrata in every state and province except Kansas (FIG. 16). Therefore the fungus should eventually be found in every state of the Union except possibly Kansas and Nebraska, and from all of the Canadian provinces.

#### POLYPORUS SPRAGUEI

A species well distributed through the eastern half of the United States (FIG. 11). A collection was made by Faull at Toronto, Ontario, and Zeller has reported it from Washington. I have not seen this last specimen. It occurs on a variety of species of *Quercus* and more rarely on other hardwood genera. The range of *Quercus alba* (FIG. 12) covers its distribution as now known. Other acceptable species of *Quercus* overlap the present known range of the fungus, however. I predict future additions to the range from Vermont, Rhode Island, Maryland, Delaware, South Carolina, Alabama, Mississippi, Florida, eastern Texas, eastern Oklahoma, Kentucky, Minnesota, North and South Dakota, and probably southern Quebec.

## POLYPORUS TEXANUS

This is a species of the far southwest, known at present only from Texas and Arizona. The host is *Prosopis juliflora*, one of the mesquites of that region. There is no reason to suppose that the fungus does not occur in New Mexico and probably in Oklahoma. *Prosopis pubescens* is another species of the region reaching sizes sufficiently large to provide a substratum. The fungus has not been reported on this host but very likely will be found on it and there is a strong possibility that the range will be extended to Utah, Nevada, and California. Even Nebraska and Louisiana are likely eventually to be found to be within its range. Since it has been reported on no other host, the species is probably host-limited in its range.

## SUMMARY

This paper is an attempt to predict the eventual range of certain species of pileate Polyporaceae in the United States and Canada. The procedure has been to compare maps showing the present known range of each species of fungus with maps showing the distribution of the major hosts or substrata. From these, predictions are made, both as to the filling of gaps in our present knowledge of distribution and as to the possible extensions of ranges that the future will disclose. The relation of certain climatic factors to distribution are briefly discussed. Some of the pitfalls of such a procedure are pointed out.

Attention is called to the fact that our herbaria could be greatly enriched from this standpoint if more local collectors would send in specimens. Also collections of species from states and provinces where gaps are indicated would be most welcome to the writer.

## EXPLANATION OF FIGURES

Fig. 1, known distribution of *Fomes fraxinophilus*. 2, combined ranges of *Fraxinus nigra* and *F. pennsylvanica lanceolata*. 3, known distribution of *Polyporus ludovicianus*. 4, distribution of *Quercus nigra* and *Liquidambar styraciflua*. The hatching indicates the range of the latter beyond the former species. 5, known distribution of *Polyporus pinsitus*. 6, range of *Juniperus virginiana*. 7, known distribution of *Lenzites betulina*. 8, combined ranges of four species of hardwoods which together give acceptable substrata for *Lenzites betulina* in every state and province. The species

included are: *Carya cordiformis*, *Ulmus americana*, *Populus tremuloides*, and *Fraxinus pennsylvanica lanceolata*. 9, known distribution of *Fomes Everhartii*. 10, combined ranges of *Quercus alba* (stippled) and *Q. macrocarpa*, two acceptable substrata for *F. Everhartii*. 11, known distribution of *Polyporus Spraguei*. 12, combined ranges of *Quercus alba* (stippled) and *Q. macrocarpa*, both acceptable substrata for *P. Spraguei*. 13, known distribution of *Fomes conchatus*. 14, combined ranges of *Fraxinus nigra* and *F. pennsylvanica lanceolata*, substrates for *Fomes conchatus*. 15, known distribution of *Polyporus Schweinitzii*. 16, combined ranges of *Pinus taeda*, *P. echinata*, *P. Strobus*, and *P. ponderosa*, indicating suitable substrata for *P. Schweinitzii* in every state and province except Kansas. 17, known distribution of *Polyporus fibrillosus*. 18, range of *Abies balsamea* in the east and *Pseudotsuga taxifolia* in the west, both suitable substrata for *Polyporus fibrillosus*. 19, known distribution of *Polyporus betulinus*. 20, range of *Betula lutea*, *B. papyrifera*, and *B. nigra* in the east and *B. papyrifera occidentalis* and *B. fontinalis* in the west. *Polyporus betulinus* is not known to occur on either *B. fontinalis* or *B. nigra*. 21, known distribution of *Fomes Pini*. 22, range of *Pinus Strobus* and *P. echinata* in the east, and of *P. ponderosa* in the west, the two ranges connected in northern Canada by the ranges of several coniferous species including *Pinus Banksiana*, *Larix laricina*, etc., giving a suitable substratum for *Fomes Pini* in every state and province except Kansas. 23, known distribution of *Polyporus cinnabarinus*. 24, combined ranges of *Fraxinus pennsylvanica lanceolata* and *Populus tremuloides*, both acceptable substrata for *Polyporus cinnabarinus*. 25, known range of *Polyporus dryophilus*. 26, range of various species of oaks in the eastern half and of several western species, giving suitable substrata for *Polyporus dryophilus* in all the states except possibly Idaho, Montana, and Colorado, although not reported on all of the hosts here included. 27, known range of *Polyporus abietinus*. 28, range of various coniferous species all of which are acceptable hosts for *Polyporus abietinus*, thus giving suitable substrata in every state and province. 29, known range of *Polyporus delectans*. 30, combined ranges of *Acer rubrum*, *A. Saccharum* in the east and of *Quercus Garryana* in the west, all of which are suitable substrates for *Polyporus delectans*.

## THE ASPERGILLUS NIDULANS GROUP

CHARLES THOM & KENNETH B. RAPER

(WITH 6 FIGURES)

*Aspergillus* (*Sterigmatocystis*) *nidulans* was described by Eidam in 1883. Since that time the general type of organism covered by his diagnosis has become fairly well known and certain striking characters have become recognized as defining a number of cosmopolitan strains or species, commonly referred to as constituting the *Aspergillus nidulans* group. These characters are as follows: (1) Short columnar heads (FIG. 5D) with primary and secondary sterigmata (FIG. 1C); (2) smooth walled conidiophores (FIG. 1C) more or less browned, usually sinuate (FIG. 1B), commonly less than  $200\ \mu$  long and terminating in dome-like or hemispherical vesicles (FIG. 1C); (3) small echinulate conidia  $3\text{--}4\ \mu$  in diameter; (4) brittle perithecia with walls of one cell thickness; (5) quickly ripening ascospores, purple-red in color, and with equatorial banding (FIG. 4); and (6) large, thick walled, globose bodies, termed "hülle cells" by Eidam (FIG. 1D), forming an irregular layer about the perithecia (FIG. 3).

In germination the ascospores of this group, like those of the *Aspergillus glaucus* (or *Eurotium* group), swell and the wall splits into two halves or "valves" along the equatorial line. Since they are red in color, the valves stand out conspicuously on opposite sides of the developing germ tube.

Wehmer in 1901 incorporated Eidam's description into his survey of *Aspergillus*, without acquaintance with the species in culture, placing it among his section *Microaspergilli* on account of the measurements of the conidial apparatus in contrast to those of such large species as *A. niger*.

Thom and Church in 1918 recognized striking variations among ascospores in strains showing the general characters of *A. nidulans* but did not propose changes in nomenclature. The same discussion was repeated in their monograph of the *Aspergilli* in 1924. In the

intervening period, many more strains of this group have been examined in culture. Careful study of the ascospores and correlation of ascospore and colony characters convince us that the series contains at least 5 species and one or more varieties which

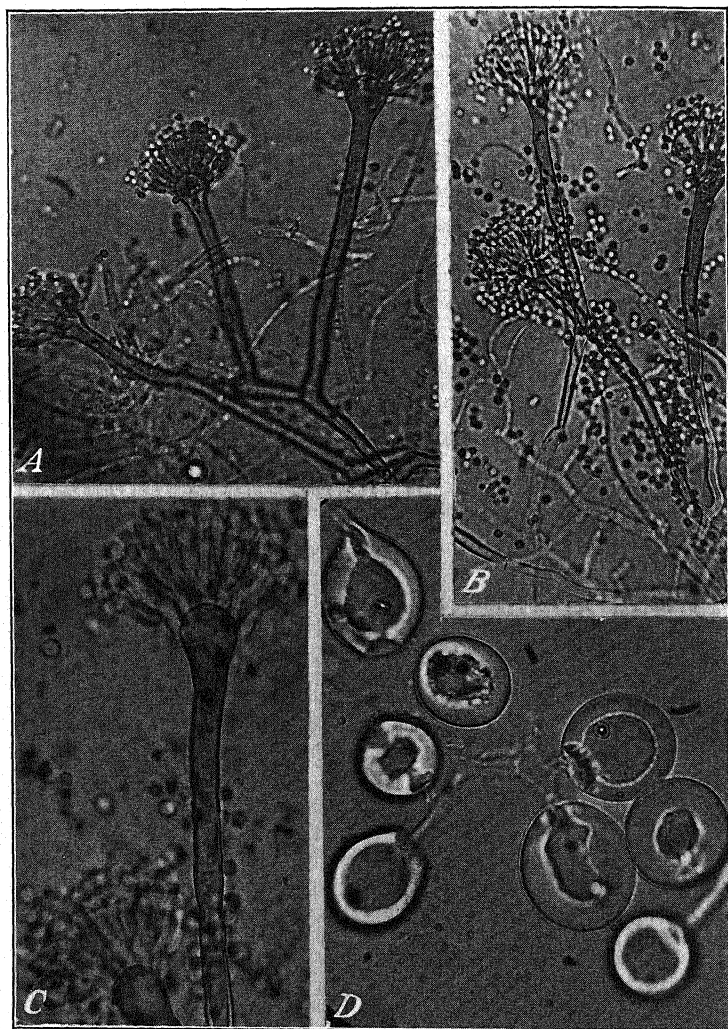


FIG. 1. *A* and *B*, conidial fructifications of *Aspergillus nidulans* showing the general character of the heads and conidiophores and the manner in which they arise from the vegetative mycelium,  $\times 370$ ; *C*, conidial head showing sterigmata in two series, hemispherical vesicle and smooth conidiophore,  $\times 740$ ; *D*, sterile, thick walled, hülle cells.

are readily distinguished by microscopic examination. Only organisms in our culture collection are included in this study. The designation "*A. nidulans* series" remains justified because of the basic characters common to all of the forms studied.

Consideration as to what section of this large series of related organisms should carry the name *A. nidulans* has led to the selection of a group of strains with smooth walled ascospores bearing narrow crests (FIG. 4A) and commonest among the members of the group as judged by frequency of occurrence among the cultures examined. One can hardly suppose that so good an observer as Eidam would have failed to note the rough walls on some spores (FIG. 4C), very wide crests on others, or the stellately lacerated crests of *A. varicolor* (FIG. 4D), had these been present.

All of the strains encountered in the group have grown well in Czapek's solution agar.<sup>1</sup> Other media likewise support good growth, but present different cultural pictures. When, for example, malt agar was used, the mass of conidial heads was greatly increased. Upon potato-dextrose the culture picture was intermediate between the two. When 20 per cent sucrose was used in Czapek's basal solution there was a great increase in vegetative mycelium but little increase in conidial or perithecial development. However, since these media offered no advantages over Czapek, that formula was used in the comparative work reported here.

The series has been arranged into an arbitrary key as follows:

Ascospores present

Ascospores smooth walled

Equatorial ridges two in number

Ridges 0.5–1.0  $\mu$  wide, margin entire

Conidial heads green ..... *A. nidulans*  
No. 4640.5 and others

Conidial heads white ..... *A. nidulans* mut. *albus*  
No. 5616.2

Ridges 1.5–1.8  $\mu$  wide, margin entire ..... *A. nidulans* var. *latus*  
No. 110

Ridges 3.0 to 4.0  $\mu$  wide, margin dissected, starlike  
*A. varicolor*  
Nos. 5602.3 and 5667.498

Equatorial ridges four in number ..... *A. quadrilineatus*  
No. 4138.N8 and others

<sup>1</sup> Czapek's solution agar: Water 1000 cc., sodium nitrate 3 gms., dibasic potassium phosphate 1 gm., magnesium sulfate 0.5 gm., potassium chloride 0.5 gm., ferrous sulfate 0.01 gm., sucrose 30 gms., and agar 12.5 gms.

Ascospores rough walled .....	<i>A. rugulosus</i> No. 4138.T11 and others
Ascospores lacking .....	<i>A. unguis</i> No. 5076.1 and others

ASPERGILLUS NIDULANS (Eidam) Wint. in Rab. Krypt.-Fl. 1<sup>2</sup>:  
62. 1884.

Syn. *Sterigmatocystis nidulans* Eidam in Cohn, Beitr. Biol.  
Pflanzen 3: 392-411. pl. 20-22. 1883.

Colonies upon Czapek's solution agar plane, spreading broadly, dark cress green (Ridgway, Pl. XXXI) from abundant conidial heads during the first two weeks (FIG. 2A); perithecia developing from the center of the colony outward after the first few days, separately produced, often abundant; sectoring occasional; reverse of colony in varying shades of purplish red during the growing period, becoming very dark in age. Heads short, columnar, ranging from 40 to 80  $\mu$  by 25-40  $\mu$ , commonly 60 to 70 by 30 to 35  $\mu$ ; stalks commonly sinuous (FIG. 1B), with walls smooth (FIG. 1C), in shades of cinnamon brown, ranging from 60 to 130  $\mu$ , commonly 75 to 100  $\mu$  in length, about 2.5 to 3  $\mu$  near the foot, increasing to 3½ to 5  $\mu$  below the hemispherical vesicle (FIG. 1C); vesicle 8 to 10  $\mu$  in diameter; sterigmata in two series (FIG. 1C), primary 5 to 6 by 2 to 3  $\mu$  and secondary 5 to 6 by 2 to 2.5  $\mu$ ; conidia globose, rugulose, 3 to 3.5  $\mu$  in diameter, green in mass.

Perithecia developed separately within or upon the conidial layer (FIG. 2A), globose, ranging from 100  $\mu$  to 175  $\mu$  in diameter, commonly 125-150  $\mu$ , with outer layer a yellowish to cinnamon colored envelope of scattered hyphae bearing hülle cells up to 25  $\mu$  in diameter; wall composed of one layer of cells, dark reddish purple; in ripening becoming a mass of 8-spored asci which break down quickly leaving the ascospores free. Ascospores purple-red, lenticular, smooth walled with 2 equatorial crests (FIG. 4A), spore bodies about 3.8 to 4.5  $\mu$  in length by 3.5 to 4  $\mu$  in breadth, equatorial crests plaited with margin sinuous and entire ranging from 0.5 to 1  $\mu$  in width (Table I).

Diagnosis based primarily upon culture 4640.5 obtained from the Bainier collection in Paris. Other strains assigned to Eidam's species included many isolations from American soil and decaying vegetation, as well as cultures from European contributors. Common.

The range of ascospore measurements found in the cultures compared is shown in the accompanying table.

TABLE I  
 ASCOSPORE VARIATION IN STRAINS OF *Aspergillus nidulans*

Culture number	Overall dimension of spores	Width of crests	Dimensions of spore bodies
5541.L29 .....	6.2-6.6 $\times$ 3.6-3.8 $\mu$	1.0 $\mu \pm$	4.2-4.6 $\times$ 3.6-3.8 $\mu$
4673 .....	6.0-6.6 $\times$ 3.6-3.9 $\mu$	1.0 $\mu \pm$	4.0-4.6 $\times$ 3.6-3.9 $\mu$
5167 .....	6.0-6.4 $\times$ 3.6-3.8 $\mu$	1.0 $\mu \pm$	4.0-4.4 $\times$ 3.6-3.8 $\mu$
5616.1 .....	5.4-5.8 $\times$ 3.6-3.8 $\mu$	0.6-0.8 $\mu$	4.0-4.4 $\times$ 3.6-3.8 $\mu$
5616.2 <sup>2</sup> .....	do	do	do
5357.P10 .....	5.4-5.8 $\times$ 3.6-3.9 $\mu$	0.6-0.8 $\mu$	4.0-4.4 $\times$ 3.6-3.9 $\mu$
4640.5 .....	5.4-5.8 $\times$ 3.6-3.8 $\mu$	0.7-0.8 $\mu$	3.9-4.3 $\times$ 3.6-3.8 $\mu$
5335.169 .....	5.0-5.6 $\times$ 3.7-4.0 $\mu$	0.5-0.6 $\mu$	3.9-4.5 $\times$ 3.7-4.0 $\mu$
5456 .....	5.0-5.4 $\times$ 3.6-3.8 $\mu$	0.5-0.6 $\mu$	4.0-4.4 $\times$ 3.6-3.8 $\mu$
B-368 .....	4.8-5.4 $\times$ 3.6-3.8 $\mu$	0.5-0.6 $\mu$	3.8-4.4 $\times$ 3.6-3.8 $\mu$
B-480c .....	4.8-5.2 $\times$ 3.6-3.8 $\mu$	0.5 $\mu \pm$	3.8-4.2 $\times$ 3.6-3.8 $\mu$

<sup>2</sup>White mutant from culture No. 5616.1; described by Yuill as *Aspergillus nidulans* mut. *albus*.

In assigning Eidam's species name to the members of this series it is obvious that there are discrepancies. He described the perithecium as having a firm almost sclerotoid wall, whereas the wall is found to contain but one layer of cells. He figured the asci as few and scattered in a mycelial matrix within which ascospore production occupied many weeks. One isolated strain in our collection produces asci in this manner. For it a varietal name, *A. nidulans* var. *latus*, is here proposed on account of very broad crests on the ascospore in contrast to the usual types in *A. nidulans* which come much more closely to those indicated in Eidam's figures.

*A. nidulans* mut. *albus* Yuill, in publication Jour. of Botany (London).

Colonies of the variety on Czapek's solution agar differ from the species in entire absence of green color. The ascospores have the characters of the species.

Culture obtained by Yuill as a mutant from a normal green strain of *A. nidulans* under investigation in his laboratory. Our record number is 5616.2; the normal and parent strain is 5616.1.

#### ***A. nidulans* var. *latus* var. nov.**

Colonies on Czapek's solution agar differing from the species in colony development characterized by a felt of predominantly sterile mycelium (FIG. 2B); few conidial heads; fairly abundant perithecia developed in the mycelial felt and each surrounded by a thick covering of hülle cells (FIG. 3C), very slowly ripening and



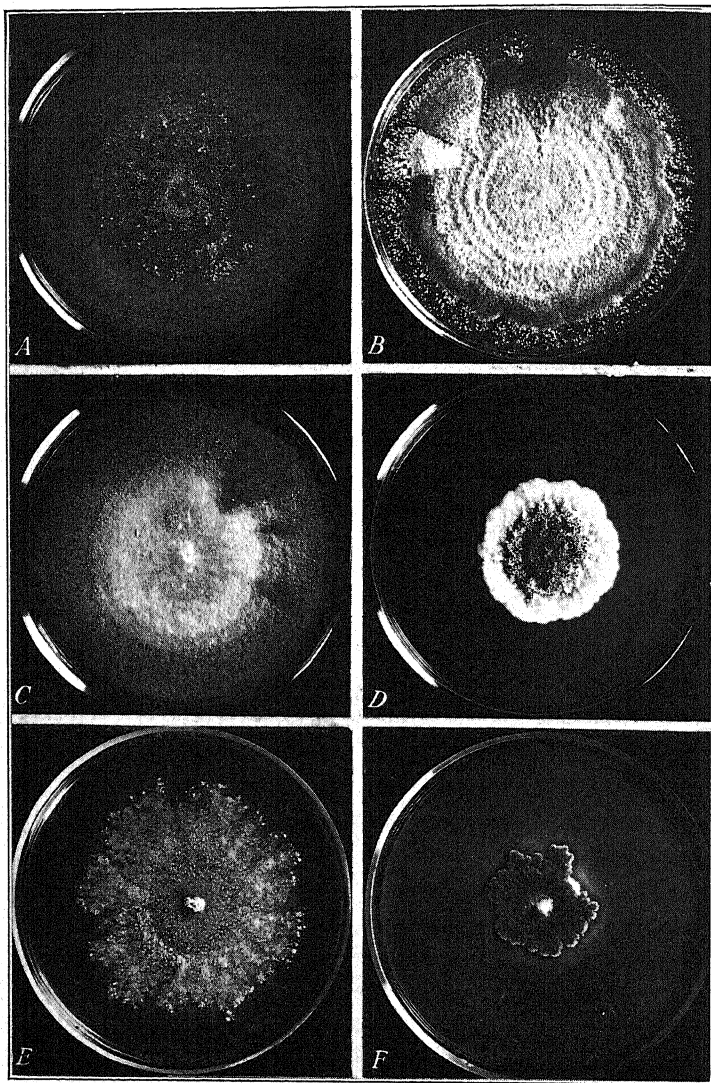


FIG. 2. Comparative growth of different species of the *Aspergillus nidulans* group upon Czapek's solution agar; 3 weeks old.  $\times \frac{1}{2}$ . A, *A. nidulans*, predominantly conidial with scattered perithecia throughout; B, *A. nidulans* var. *latus*, predominantly perithecial with conidial heads largely confined to a marginal zone; C, *A. quadrilineatus*, predominantly perithecial but with abundant conidial heads in marginal zone and in localized sectors; D, *A. rugulosus* almost wholly perithecial, the perithecia being piled in the central area; E, *A. variegatus*, predominantly perithecial with large, pseudo-stalked perithecia at the colony center and smaller unstalked ones in out-lying areas; F, *A. unguis*, wholly conidial with no perithecia present.

containing few and scattered asci in abundant sterile mycelium. Ascospore bodies smooth walled, purple-red,  $3.8-4.5$  by  $3.5-4$   $\mu$ , with crests  $1.5$  to  $1.8$   $\mu$  in width.

Type culture No. 110 received from the Centraalbureau in 1909 and remaining constant in culture since that time. Its antecedent history is not known.

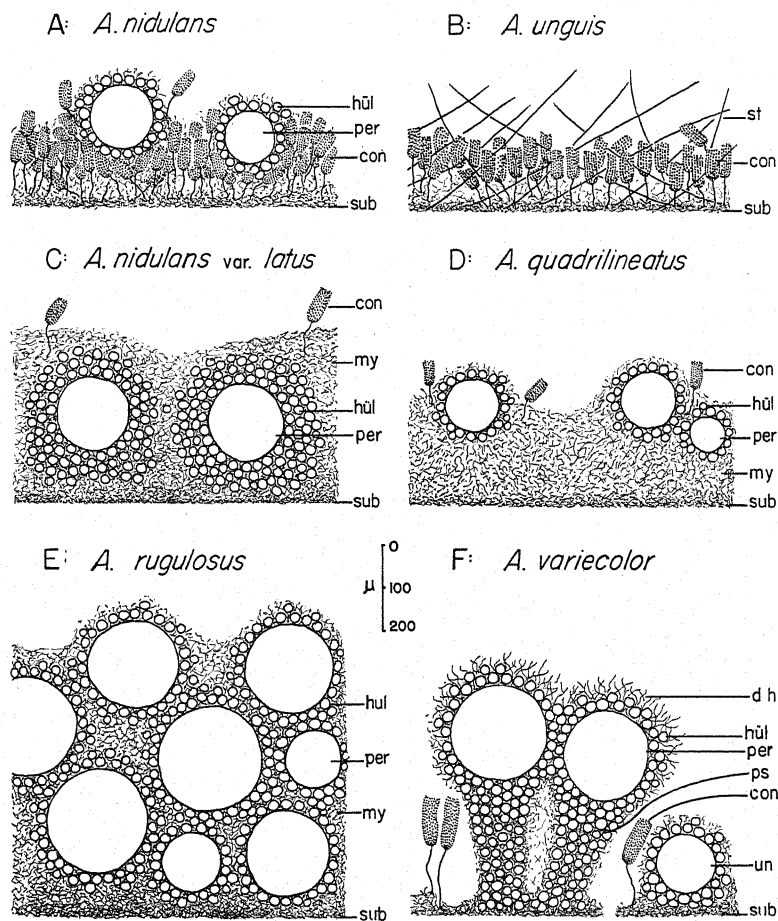


FIG. 3. Diagrammatic representations of cross sections of colonies of different species of the *Aspergillus nidulans* group showing the relative abundance of conidial heads and perithecia and the manner in which these structures are borne: con., conidial heads; d.h., mantle of divergent hyphae; hül., hülle cells; my., mycelial felt; per., perithecia; ps., pseudostalk of hülle cells and sterile hyphae; st., long, thick walled, sterile hyphae; sub., substratum; and un., unstalked perithecia. Scale approximate.

***Aspergillus quadrilineatus* Thom & Raper, sp. nov.**

Coloniis in agaro Czapeki diffusis, planis vel rugosulis, leniter floccosis, centro purpureo-griseis, et margine interdum areis olivaceis conidicis; reverso purpureo-rubro; capitulis breve columnaribus, fere  $60-70 \times 30-35 \mu$ , interdum majoribus vel minoribus; stipitibus sinuosis glabro-tunicatis, brunneolis,  $50-75 \mu$  longis,  $3.5-4.5 \mu$  latis, ad areas vesiculosas hemisphaericas usque  $7.5-9 \mu$  dilatis; sterigmatibus primariis  $5-6 \times 2-3 \mu$ , secundariis  $5-7 \times 2-2.5 \mu$ ; conidiis globosis, pallide flavo-viridibus, rugulosis,  $3-4 \mu$  diam.; peritheciis e cellulis "hülle" involutis, pallide brunneolis, sphaericis, in mycelio immersis, circa  $125-150 \mu$  diam. strato cellularum "hülle" incluso, pariete stratum cellulae unicae crasso, mox maturantibus; ascis in axe longo  $10 \mu$  diam., maturis dissolventibus et ascoporas liberantibus; ascoporis purpureo-rubris, lenticularibus, sine cristis  $4-4.8 \times 3.4-3.8 \mu$ , cristis duobus plicatis circa  $0.5 \mu$  latis et duobus secundariis parallelibus angustioribus interdum indistinctis ornatis.

In culturis ex solo, New Jersey, Texas, Colorado, Louisiana, Maryland.

Colonies on Czapek's solution agar spreading, plane or slightly wrinkled, with tendency toward floccosity, central area gray with a definite purplish tinge, and olive-green conidial areas toward the margin, occasional as sectors (FIG. 2C); perithecia developing separately but abundantly throughout the colony; reverse purplish red; heads short columnar, green, mostly 60 to 70 by 30 to 35  $\mu$ , occasionally larger or smaller; stalks sinuate, smooth walled, dull brownish in color, 50 to 75  $\mu$  in length by 3.5 to 4.5  $\mu$  wide, broadening to 7.5 to 9  $\mu$  at the hemispherical vesicular areas; primary sterigmata 5 to 6 by 2 to 3  $\mu$ , secondary sterigmata 5 to 7 by 2 to 2.5  $\mu$ ; conidia globose, pale yellow-green, rugulose, 3 to 4  $\mu$  in diameter; perithecia enveloped by hülle cells, light brownish in color, spherical, partially embedded in the mycelial felt (FIG. 3D), about 125 to 150  $\mu$  in diameter including the enveloping hülle-cell layer, with perithecial wall 1-cell layer in thickness, ripening quickly and with ripe asci breaking down to leave the ascospores free; ascospores purple-red, lenticular, with smooth wall, with spore body 4 to 4.8  $\mu$  by 3.4 to 3.8  $\mu$ , and with two plaited equatorial crests about 0.5  $\mu$  in width paralleled by a secondary narrower pair (FIG. 4B) which are sometimes indistinct.

Type No. 4138.N8 from New Jersey soil and kept in culture since 1916. Other strains examined include isolations from Texas, Colorado, Louisiana, and Maryland.

***Aspergillus rugulosus* Thom & Raper, sp. nov.**

Coloniis in agaro Czapeki lente et restricteque crescentibus, plicatis vel rugosis, 2-3 mm. altis, saepe denique centro fissis, purpureo-griseis vel

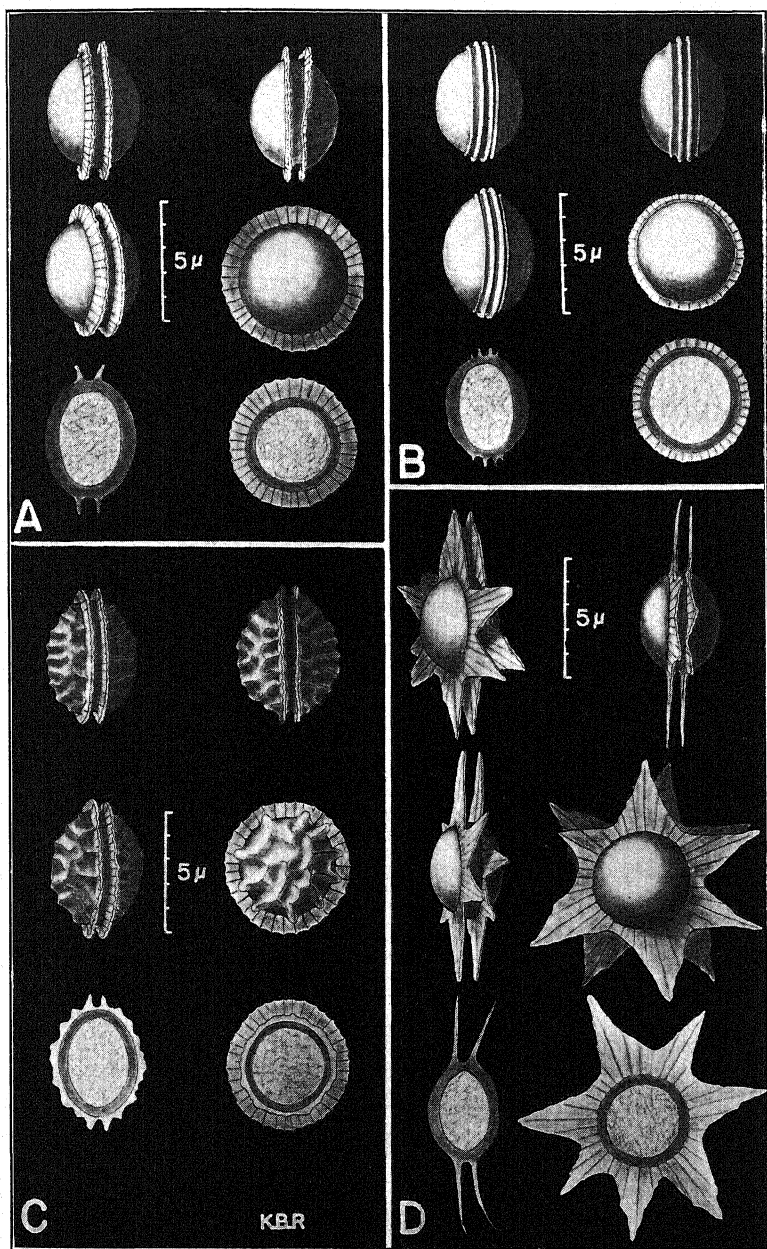


FIG. 4. Ascospores of different species of the *Aspergillus nidulans* group. A, *A. nidulans*; B, *A. quadrilineatus*; C, *A. rugulosus*; D, *A. varicolor*. In each species upper left and right and center left spores represent surface, profile views; center right, surface in face view; lower left, optical section in profile; and lower right, optical section in face view.

vestustis purpureo-brunneis, capitulis viridibus sparsis; reverso purpureo-rubro; capitulis conidioferis breve columnaribus  $75-100 \times 30-40 \mu$ ; stipitibus sinuosis, glabro-tunicatis, pallide brunneis, gracilibus, usque  $5 \mu$  latis, in hemisphaerios vesiculosos  $8-10 \mu$  diam. dilatis; sterigmatibus primariis  $7-8 \times 3-3.5 \mu$ , secundariis  $6-7 \times 2.5-3 \mu$ ; conidiis globosis, viridibus, rugulosis,  $3-4 \mu$  diam.; peritheciis copiosis, saepe in stratis duobus vel tribus in mycelio immersis, quoque e hyphis et cellulis "hülle" atrobrunneis cincto, globosis,  $225-350 \mu$  tegumento mycelico incluso, pariebus atro-rubro-purpureis, stratum cellulae unicae crassis; ascis in axe longo  $9-11 \mu$  diam., mox maturantibus, dissolventibus et ascosporas liberantibus; ascosporis purpureo-rubris, sine cristis  $4-4.4 \times 3.6-3.8 \mu$ , tunicis conspicue rugosis, cristis duobus plicatis aequatorialibus peripherice sinuatis et integris  $0.5-0.6 \mu$  latis ornatis.

In culturis ex solo, New Jersey, Texas, Nebraska.

Colonies on Czapek's solution agar slowly and restrictedly growing (FIG. 2D), buckled or wrinkled in a mass 2-3 mm. deep, enveloping abundant perithecia at different depths, often eventually splitting in the central area, purple-gray to purple-brown in age, with green heads sparsely produced and hence not generally evident, occasionally seen as small groups and marginal extensions into drying media; reverse in shades of deep purple-red; conidial heads short columnar, 75 to 100 by 30 to  $40 \mu$ ; stalks sinuous, smooth walled, pale brownish in color, 50 to  $80 \mu$  long, slender, varying up to  $5 \mu$  in width, then enlarging to vesicular hemispheres 8 to  $10 \mu$  in diameter; primary sterigmata 7 to 8 by 3 to  $3.5 \mu$ , secondary sterigmata 6 to 7 by 2.5 to  $3 \mu$ ; conidia globose, green, rugulose, 3 to  $4 \mu$ .

Perithecia very abundant, often imbedded in the mycelium as 2 or 3 layers and each surrounded by hyphae and dark brown hülle cells (FIG. 3E), globose, 225 to  $350 \mu$  in diameter including mycelial coverings, with dark reddish purple walls of one cell thickness, quickly ripening and breaking down to leave ascospores free; ascis 10 to  $11 \mu$  in long axis; ascospores purple-red, lenticular, walls conspicuously rugulose (FIG. 4C), with spore bodies 4 to 4.4 by 3.6 to  $3.8 \mu$ , and with 2 plaited equatorial crests with sinuate and entire margins about 0.5 to  $0.6 \mu$  in width.

Cultures studied include Type 4138.T11 from New Jersey soil, as discussed in The Aspergilli, p. 138, and also isolates from Washington, D. C., Texas, Nebraska, and California. Believed to be common.

Culturally and microscopically the above strains present similar pictures, with the exception of the strain recently received from Bliss in California (our No. 5667.455). In contrast to the others, this culture produces abundant conidial heads and relatively fewer

perithecia. The ascospores and conidial structures, however, duplicate those of the typical strains; hence we do not at present feel warranted in designating this as a variety, or otherwise separating it from the species *A. rugulosus*.

A. VARIECOLOR (Berk. & Br.) Thom & Raper.

*Emericella varicolor* Berk. & Br. in Berkeley, Introd. Crypt. Bot. p. 340-341; fig. 76. 1857. See Patouillard, Bull. Soc. Myc. Fr. 7: 43-49. pl. 4. fig. 6-12. 1891.

*Inzengaea erythrospora* Borzi, Jahrb. Wiss. Bot. (Pringsheim) 16: 450-463. pl. 19, 20. (1884) 1885.

*Emericella medias* Chowdhury & Mathur, Ann. Myc. 36: 61-63. 1938.

*Aspergillus stellatus* Curzi, Rend. Accad. Naz. Lincei 19: 424-428. fig. 1. 1934.

Colonies in Czapek's solution agar with vegetative mycelium largely submerged, sparse, spreading slowly in the agar (FIG. 2E), producing green heads freely in the center of the colony, sparsely throughout, large gray perithecia produced in clusters in center and at the margin, with smaller perithecia scattered through the intervening thinner areas of the colony (FIG. 5A); reverse color in shades of purple-red. Conidial heads green, columnar (FIG. 5D), relatively long, mostly 100-200, occasionally up to 300  $\mu$  by 30-40  $\mu$ ; stalks arising directly from submerged hyphae, straight, with smooth walls, cinnamon-brown in color, mostly 140 to 200  $\mu$  long by 3 to 5  $\mu$  in diameter, broadening gradually toward vesicular hemispheres about 8 to 10  $\mu$  in diameter; primary sterigmata 7 to 8 by 3 to 4  $\mu$ , secondary sterigmata 8 to 9 by 2.5 to 3  $\mu$ ; conidia globose, rugulose, 3 to 3.5  $\mu$ ; perithecia when clustered (FIG. 5Aa) 300 to 400  $\mu$  in diameter surrounded by a felt of hyphae and hülle cells and supported by masses of hyphae and hülle cells forming false stalks (FIG. 3F), giving the structures a pyriform appearance (FIG. 5B); scattered perithecia much smaller (FIG. 5C) and with envelope of supporting cells often much reduced in mass; hülle cells abundant and essentially like those of the species *A. nidulans*.

Perithecial wall when stripped of enveloping cells purple-red, brittle, composed of a single layer of cells; asci quickly ripening and breaking down to leave the cavity filled with ascospores; ascospores purple-red, with spore bodies lenticular and 3.6 to 4 by 2.8 to 3  $\mu$ , with two prominent equatorial crests, up to 3.5  $\mu$  in width, plaited and cut to give a stellate appearance to the ascospores (FIG. 4D).

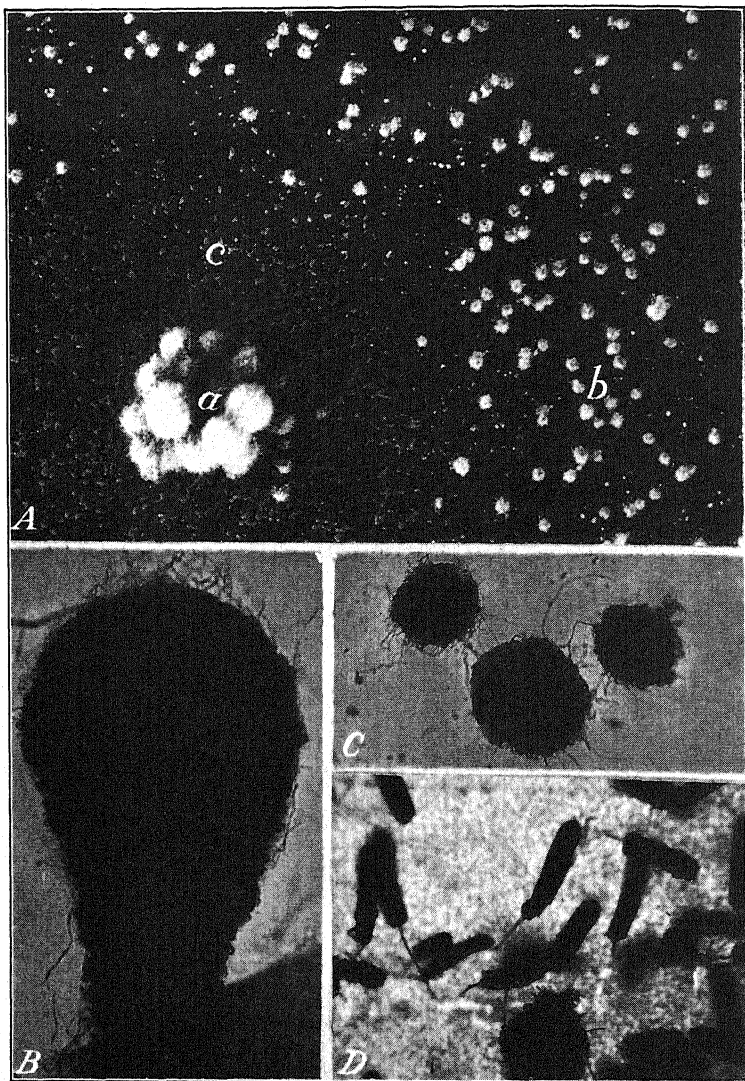


FIG. 5. *Aspergillus varicolor*. A, central area of colony; a, cluster of large pseudostalked perithecia; b, scattered, smaller, unstalked perithecia (see also figure 3F); c, scattered conidial heads,  $\times 6$ ; B, enlarged view of large, pseudostalked perithecium,  $\times 65$ ; C, enlarged view of small, unstalked perithecia,  $\times 65$ ; D, enlarged view of conidial heads,  $\times 65$ .

The above description is based primarily upon a culture received from Prof. Verona in Italy and carried in our collection as No. 5602.3.

Bliss has recently forwarded a culture (our No. 5667.498) isolated from date fruits in California which differs from the above in the following particulars: (1) Conidial heads are produced abundantly, (2) the mycelium is not predominantly submerged, and (3) the colonies in reverse are deep purple. However, the ascospores of the two strains are strikingly similar in size and pattern, the perithecia of each appear pyriform in shape, and the conidial structures of the two are essentially alike. Consequently we do not feel justified in designating the California strain as a variety, while on the other hand we hesitate to alter the cultural description of *A. varicolor* to include a strain which we have observed in culture for only a few weeks.

Since the type of ascospore described here had already been assigned to *Emericella* and *Inzengaea*, consideration of the literature of these genera is necessary.

*Emericella varicolor*, genus and species new, was described by Berkeley and Broome in 1857 as doubtfully a Gasteromycete or possibly a lichen. The perithecium with a mass of stellate spores was considered as Gastromycetous in character while what we now recognize as the "hülle" cells of Eidam (figured) suggested to him the possibility of an algal associate. Berkeley's material was also examined by Montagne and part of it deposited in the Museum d'Histoire Naturelle de Paris. This was reexamined by Patouillard in 1891 and its ascomycetous nature determined. No conidial apparatus was found by either Berkeley or Patouillard.

*Inzengaea erythrospora* as the type species of a new ascomycetous genus was figured and described by Borzi in 1885, showing stellate red ascospores, and the hülle cells of Eidam. Borzi's figure showed a coremium-like conidial apparatus which was designated *Coremium Borzianum* by Saccardo. Ed. Fisher in 1893 transferred the species to *Emericella* of Berkeley and placed the genus next to *Aspergillus* in the "*Pflanzenfamilien*." Saccardo (in Syll. 9: 610) on the other hand accepted *Inzengaea* and dropped *Emericella* because of the errors in description and placement by Berkeley. Borzi figured the spores of *A. varicolor* (*Inzengaea*



*erythrospora*) correctly but obviously misinterpreted the germination of the ascospores since he showed them splitting as if turned 90°, bringing the crest perpendicular to the center of the valve instead of attached to its edges.

There the taxonomic situation stood until Vuillemin in 1927 concluded that the ascosporic apparatus, the stellate red ascospores and the cells of Eidam, as clearly shown in their figures and material, showed the identity of *Emericella* and *A. nidulans*. He therefore transferred *A. nidulans* to *Emericella* as the oldest established genus and apparently did not even consider *Inzengaea*.

Ciferri has recently completed a study of *Emericella varicolor* embracing cultural investigations together with a review of the literature of the genus. He did not recognize the close relationship of this fungus to *Aspergillus nidulans*, and was apparently unmindful of the likeness of their conidial structures and the essential similarity of their perithecia and ascospores.

In 1934 Curzi described as *Aspergillus stellatus* a fungus characterized by hülle cells and red, stellate ascospores. However, he apparently did not know of either Berkeley's or Borzi's earlier designation of a similar fungus. It is unfortunate that his exceedingly descriptive binomial must be reduced to synonymy.

Fortunately for this discussion, cultures No. 5602.3 and 5667.498 presented both the stellate spores and apparently stalked perithecia figured by Berkeley, Patouillard and Borzi. (Compare figures 3F and 5B with Berkeley's figure 76a, Patouillard's figures 7 and 8, plate 4, and Borzi's figure 10, plate 19.) This made possible a restudy of the whole morphologic situation from fresh material. The perithecial body itself was found not to be stalked but to rest upon a sterile mass of hülle cells and mycelium giving the superficial appearance noted by earlier observers.

The coremium of Borzi remains unaccounted for. Obviously in Borzi's discussion the material was rotten olives and very old. No cultures were made. The conidia producing apparatus figured differs essentially in type from the conidial apparatus of the *Aspergillaceae* with which Fischer correctly placed *Emericella* because of its perithecia and ascospores. We are convinced that the coremia belonged to some other fungus.

It is not possible to separate the perithecium of this fungus from

that of the other species in the *A. nidulans* group nor are there characters to take this type of perithecium out of a genus with the yellow perithecium of the great *A. glaucus* series of species which are widely known. Consistent with the policy of keeping the Aspergilli in one group, both *Emericella* and *Inzengaea* are dropped for purposes of this discussion.

*ASPERGILLUS UNGUIS* (Emile-Weil & Gaudin) Emend. Thom & Raper.

*Sterigmatocystis unguis* Emille-Weil & Gaudin, Arch. Med. Expt. Anal. Path. Paris 28: 463-465. fig. 4. 1919.

Colonies on Czapek's solution agar restrictedly growing, plane, spreading at the margin as irregular lobes (FIG. 2F), yellowish-

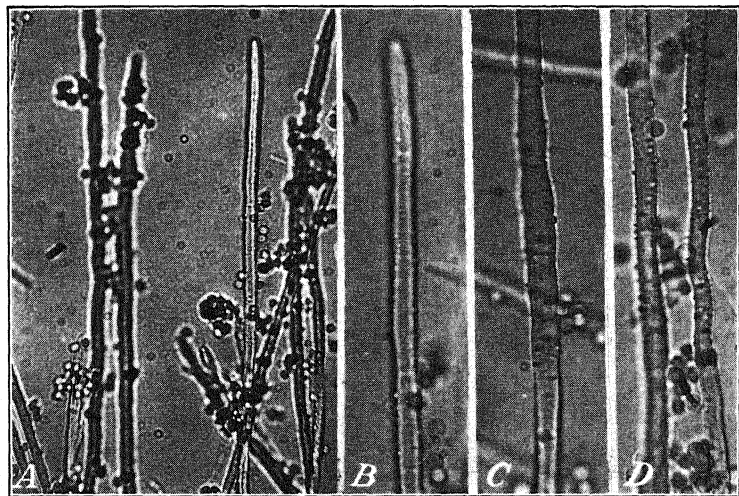


FIG. 6. Sterile spicule hyphae of *Aspergillus unguis*. A, cluster of sterile hyphae,  $\times 370$ ; B, apex of sterile hypha,  $\times 740$ ; C and D, mid portions of sterile hyphae showing thick roughened walls,  $\times 740$ .

green, green to dark green becoming brown in age; without perithecia or hülle cells. Mycelial preparations show striking sterile, thick walled hyphae with walls in brown shades, irregularly roughened (FIG. 6), tapering to a blunt point, arising sometimes from foot-cells suggesting the origin of stalks, sometimes apparently from mycelial cells, often up to  $1000\ \mu$  or more in length, slanting

upward but usually rising only slightly above the conidial area (FIG. 3B).

Conidial heads columnar, 75 to 150 by 40 to 50  $\mu$ ; stalks smooth walled, dull brown in color, mostly 45 to 65  $\mu$  in length by 3 to 5  $\mu$  in diameter, enlarging to vesicular hemispheres 9 to 12  $\mu$  in diameter; primary sterigmata 5 to 6 by 2.5 to 3  $\mu$ , secondary sterigmata 5 to 6 by 2 to 2.5  $\mu$ ; conidia globose, rugulose, dull green, 2.5 to 3.5  $\mu$  in diam.

Cultures obtained frequently from medical laboratories apparently as more or less active pathogens but occasionally isolated from soil and decaying organic matter. The question whether the non-ascosporic members of the group have merely dropped the ascogenous phase or constitute a separate species was answered when more complete examination showed the sterile or spicule hyphae to be regularly produced in the non-ascosporic, but never found in ascosporic series.

#### SUMMARY

The *Aspergillus nidulans* group is divided into five species primarily upon the character of the ascospores produced. Differences in colony characters are also correlated with differences in ascospore pattern and further substantiate the validity of the present separation.

The following species are recognized or described as new: (1) *Aspergillus nidulans*, characterized by a smooth walled ascospore bearing two parallel, equatorial crests of 0.5 to 1.0  $\mu$  width; (2) *Aspergillus quadrilineatus*, characterized by a smooth walled ascospore typically bearing four equatorial crests; (3) *Aspergillus rugulosus*, characterized by a rough walled ascospore; (4) *Aspergillus variegator*, characterized by a smooth walled ascospore bearing two equatorial crests 3.0 to 3.5  $\mu$  in width and strongly dissected, giving the spore a stellate appearance when seen in face view; and (5) *Aspergillus unguis*, lacking perithecia and ascospores and characterized by the presence of long, roughened, sterile, spicule hyphae not found in other species.

A new variety, *Aspergillus nidulans* var. *latus*, is described, and differs from the species in the much wider crests of the ascospore and in colony character as well. A white mutant of *Aspergillus*

*nidulans* isolated and described by Yuill as *A. nidulans* mut. *albus* is accepted.

The writers are indebted to Edith K. Cash for preparing the Latin diagnoses.

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## TWO NEW SPECIES OF RUST

W. H. LONG & L. N. GOODDING

(WITH 2 FIGURES)

This paper describes two new species of rusts, namely, *Ravenelia Dysocarpae* on *Mimosa dysocarpa* and *Gymnosporangium Vauquelinae* with the aecial stage on *Vauquelinia californica* and telia on *Juniperus monosperma*.

### *Ravenelia Dysocarpae* Long & Goodding, sp. nov.

0 & II.—Pycniis et urediis ignotis; urediosporis in teliis, globosis, 15.5–21.7 microns, pallide flavida, verruculosi, poris germ. obscuris, sparsis.

III.—Teliis amphigenis plerumque epiphyllis, subcuticularibus, atro-brunneis; capitulis teliosporarum levibus, 56–80 microns diam., paraphysibus 7–10 × 43–53 microns, cystidiis hyalino; pedicello hyalino.

0.—Pycnia unknown.

II.—Uredinia not seen; urediospores in the telia, globoid, 15.5–21.7, average size for 20 spores 18.44 microns, usual size 18.6 microns, walls pale fulvous,  $1\frac{1}{2}$ –2 microns thick, uniform, closely verrucose, germ pores many, scattered.

III.—Telia amphigenous, mainly epiphyllous, scattered, irregular in shape, 1 mm. or less across, subcuticular, soon naked, blackish-brown, shining, ruptured cuticle inconspicuous; paraphyses few, intermixed very sparingly with the teliospores, spoon-shaped to clavate, 7–10 by 43–55 microns, average for ten 9.6 by 49.6, usual size 10 × 50 microns, heads thickened at apex 4–5 microns, becoming thin on lower  $\frac{1}{3}$  of head, chestnut-brown, stipe hyaline, solid, curved; teliospore heads chestnut-brown, 5–8 cells across, 55.8–80.6 microns in diameter, average for 20 heads 67.5 microns, usual size 65 microns, smooth, cysts hyaline, globoid to oblong, beneath entire head, very slowly swelling and bursting in water, not coherent, sometimes breaking away from head; pedicel hyaline, short, deciduous.

On Mimosaceae-type collected on *Mimosa dysocarpa* Benth. 5 miles south of Arivaca, Arizona, 10–1–36 by Leslie N. Goodding (Type No. 7714 Long) also collected on same host in Sycamore

Canyon about 5 miles from Ruby, Arizona, 10-3-36 by *Leslie N. Goodding* (No. 7716 Long).

***Gymnosporangium Vauqueliniae* Long & Goodding, sp. nov.**

0.—Pycniis epiphyllis, minutis, 200-270 microns latis, 100-150 microns altis.

I.—Aeciis hypophyllis, petiolicolis et floricolis, matricem deformantibus et "Hexenbesen" vel "witches-brooms" efformantibus, cylindraceis, 5-8 mm. altis 0.4-0.5 mm. latis, flavo-brunneis, ad apicem dehiscentibus; aeciosporis, globosis vel ellipsoideis, minute verruculosis,  $18.6-24.8 \times 21.7-34$  microns, episporio 3-4 microns, crasso.

III.—Teliis ramicolis, ad ramos minores interfolia evolutis, sparsis, plerumque solitariis, hemisphaericis vel globosis, 0.5-1.5 mm. diam., brunneis; teliosporis, media 1-septatis et non vel vix constrictis, dilute brunneis, ellipsoideis,  $15.4-21 \times 52.2-64.4$  microns, episporio 1.2-3 microns, crasso, quaque cellula poris germinationis 2 prope septum positis; pedicello hyalino, cylindraceo, 50-75 microns longo.

0.—Pycnia epiphyllous, numerous, scattered over entire upper surface of the leaf, punctiform, honey-yellow becoming dark brown with age, globoid, 200-270 microns in diameter by 100-150 microns high.

I.—Aecia numerous, gregarious, causing hypertrophy of leaves, peduncles and pedicels of the inflorescence forming globoid "witches-brooms" (FIG. 1) 3-10 cm. in diameter, cylindrical, 0.4-0.5 mm. in diameter by 5-8 mm. high (FIG. 2); peridium white (hyaline), rather tough, rupturing at the apex, not lacerate on sides, remaining tubular, lower portion containing undischarged spores, lead color; peridial cells usually seen in face view, hyaline, narrowly lanceolate to lozenge-shaped, remaining straight when wet,  $25-31 \times 62-93$  microns, usual size  $28 \times 85$  microns, oblong in side view, 22-31 microns thick, outer wall smooth about 3 microns thick, inner and side walls closely spinulose; aeciospores globoid to broadly elliptical,  $18.6-24.8$  by  $21.7-34.1$  microns, usual size  $18.6 \times 24.8$  microns, walls fulvous, 3-4 microns thick, germ pores 7-10, scattered, finely verrucose.

On Rosaceae. Type for pycnia and aecia on *Vauquelinia californica* Sarg. (an evergreen) on Superstition Mountain (el. 4,000 ft.) about 25 miles east of Mesa, Arizona, Nov. 1, 1935, and May 5, 1939, by *L. N. Goodding* (Type No. 7720 Long) and (No. 8370 Long).



FIG. 1. Upper, shows inflorescence of *Vauquelinia californica* changed into a witches-broom by the aecia of *Gymnosporangium Vauqueliniae*,  $\times 1$ ; lower, shows the aecial "horns" on a pedicel of the inflorescence,  $\times 2\frac{1}{2}$ . Note the slenderness of the horns.

II.—Uredia wanting.

III.—Telia cauliculous, forming a slight witching of the twigs, arising between the scale-like leaves on the green twigs, these showing a distinct yellowing with age, scattered, or in clusters of 2 or more individuals, hemispheric to globoid, 0.5 to 1.5 mm. in size, reddish brown, easily falling away from twigs when desiccated; teliospores 2-celled, ellipsoid, 15.4–21 by 52.2–64.4 microns, usual size  $18 \times 56$  microns, not or very slightly constricted, usually narrowed above and below, lower cell often more narrowed than the upper one; walls 1.2–3 microns thick, fulvous to hyaline, the pores 2 to each cell near septum; pedicel hyaline, cylindrical, 3–4 microns thick, occasional pedicel 9–10 microns thick, 50–75 microns long, solid, easily breaking away at base of spore.

On Juniperaceae. Type for telia collected on *Juniperus monosperma* (Engelm.) Sarg. on Superstition Mountain, Arizona, April 4, 1936, and May 5, 1939, by L. N. Goodding (Type No. 8361 Long), and (No. 8371 Long), known only from type locality.

This beautiful species of *Gymnosporangium* is unique in several ways. Its aecial stage occurs on an evergreen where it produces "witches-brooms" of the inflorescence, the first case known to the writers. "Witches-brooms" are common on the telial hosts of *Gymnosporangium* but not on the aecial host. The infected leaves are only those attached to the inflorescence and the aecia are mainly hypophyllous.



## NEW SPECIES AND TAXONOMIC CHANGES IN THE HYPODERMATACEAE

L. R. TEHON

(WITH 6 FIGURES)

Since the publication in 1935 of my studies of *Lophodermium* (15) I have had opportunity to examine numerous specimens belonging to that genus and to related genera. Some of the specimens had been collected recently, and there was among them representative material of undescribed species; others represented recently described species or had been recently mentioned in literature; and still others were *exsiccati*, or other authoritative specimens, which I examined as reference material. From them I have accumulated a miscellany of new species, taxonomic reallocations, and particular notes, which I present below.

Because the morphology and host relations of the hysterothecium have been emphasized, first by von Höhnelt (7) and later by Nannfeldt (11), Darker (3), and Tehon (15), in the classification of the Hypodermataceae, I have deemed it necessary to follow a set of criteria, based on the characteristics of the hysterothecium, which would determine the disposition of species in families and genera. The criteria I have set up do not constitute a complete system, and they are not wholly consistent; but they have at least the advantage that they exclude from the Hypodermataceae species that could not reside permanently in that family.

For inclusion in the Hypodermataceae, I have required a fungus to exhibit (1) an oval to elongated, covered ascoma containing a discoid hymenium; (2) a marginal separation of the hysterothecial wall into a cover-plate and a base-plate; (3) an elongated, morphologically defined ostiole; and (4) an ostiolar lining of periphyses. With scolecosporic species, those formerly assignable to *Lophodermium*, I have relied upon the level at which the hysterothecium is inserted in the host tissues to determine the generic assignment. But with species having stalked, clavate asci and elongated, one- to

two-celled spores, those assignable to *Hypoderma*, I have not employed the insertion level as a generic criterion.

Specimens representing three of the species I am reporting on failed to meet the requirements for inclusion in the Hypodermataceae. They were all scolecosporic; and, for reasons given in an earlier paper (14), I have assigned the species to *Clithris*, the only suitable genus in the Phacidiaceae.

These phacidiaceous specimens all possess ascomata very different in structure (FIGS. 2, 5, 6) from those of *Lophodermium* and *Hypoderma*. Although dehiscence is by means of a lengthwise opening in the roof of the ascoma, sections do not reveal the group of structures which Nannfeldt (11) termed the *Mündungsmechanismus*: there are no periphyses; there are no *Quellkörpern*; and there is no *Öffnungsmechanismus*—the “slit-band” of Darker (3); instead, the irregularity of the slit, the tapered thinness of the surrounding labia, and the absence of differentiation in structure point to an entirely mechanical method of dehiscence. The walls of the ascomata may be carbonaceous throughout (FIG. 2) or only in the roof and base (FIGS. 5, 6), and they may vary greatly in thickness. The pseudoparenchyma of the ascoma wall is continuous, and sections give no evidence that separate base-plates and cover-plates exist. Between the wall and the hymenium, along the sides of the ascoma, there is an inclosing tissue consisting of hyaline, regularly oblong, palisade-like cells, which may be regarded structurally as the exciple of the stromatically inclosed apothecium, if Nannfeldt's (11) contention that the fruiting body is an *Apothecienstroma* is accepted, or as a pressure-exerting mechanical tissue concerned with the opening of the ascoma, if a functional explanation is preferred.

***Clithris Camelliae* (Teng) comb. nov. (FIG. 6).**

*Lophodermium Camelliae* Teng, *Sinensia* 4: 138. 1933.

Apothecia foliicolous, amphigenous, scattered and few to numerous in pale yellow to ashen, often brown margined, circular spots up to 1 cm. in diameter, dull black, short- to long-oval, straight to lunate,  $350\text{--}700 \times 225\text{--}310\ \mu$ , heavily carbonized in the cover, in a much enlarged median region in the base, and at the margins, elsewhere thin and often more or less translucent; slit nearly as long as the apothecium, with labia and periphyses lacking. Paraph-

yses abundant, filiform, simple, straight or flexuous, exceeding the asci, without an apparent gelatinous case, variously bent and crushed toward the tips and interwoven to form a yellowish epithecium,  $75-155\ \mu$  long,  $1-1.5\ \mu$  wide. Asci cylindrical, straight to flexuous, bluntly and symmetrically rounded at the tips, tapered near the base to a short stalk,  $82-115 \times 5-7\ \mu$ , chiefly  $90-105 \times 5-6\ \mu$ , 8-spored. Ascospores hyaline, filiform, straight or flexuous, fasciculate in pairs in the ascus,  $62-78 \times 1-1.5\ \mu$ , without an apparent gelatinous matrix.

Type specimen: S. C. Teng, No. 1904 (No. 77 in the Metropolitan Museum, Academia Sinica, Nanking, China); type locality: Foochow, Funkien province, China; host: *Camellia* sp., on fallen leaves; specimen examined: part of the type, labeled "co-type" by Dr. Teng.

Teng (*l. c.*) has remarked that this fungus is related to *Lophodermellina hysteroioides*. Such a conclusion might readily be reached from the gross appearance of the spots and fruiting structures. Sections show, however, that it lacks the characteristic structure of an hypodermataceous form and is assignable, instead, to the Phacidiaeeae. No periphyses are present; and the apothecial opening, at first a linear slit of purely mechanical origin, is eventually enlarged by the breaking away of the carbonized cover so as to expose the hymenium freely. Although the apothecia are apparently laid down in the epidermis, they show no differentiation into morphologically separate covers and bases; and radial plates of mycelium are entirely lacking.

***Clithris leucothoicola* sp. nov. (FIG. 5).**

Apothecia follicolous, amphigenous, scattered in cinereous, unlimited spots of very variable extent, shining black, subrotund to elliptical, straight to lunate, isolated, contiguous, or merged laterally or terminally,  $330-790 \times 260-300\ \mu$ , subcuticular, heavily carbonized in the cover on each side of the slit, in a somewhat swollen median portion of the base, and at the margins, elsewhere thin and more or less translucent; opening widely, the slit nearly as long as the apothecium, erose margined, mechanically developed, and lacking periphyses. Paraphyses abundant, hyaline to yellowish, filiform, simple, straight or flexuous, without apparent gelatinization, exceeding the asci and variously crushed and bent above to form a dense yellow epithecium up to  $15\ \mu$  thick,  $120-165\ \mu$  long,  $1-1.5\ \mu$  wide. Asci cylindrical, straight to flexuous, bluntly

rounded above, tapering below to a long, slender stipe and inconspicuous foot,  $107\text{--}157 \times 5\text{--}6.5 \mu$ , 8-spored. Ascospores hyaline to faintly yellow, filiform, straight, fasciculate in pairs,  $60\text{--}110 \times .75\text{--}1 \mu$ , gelatinous matrix inconspicuous.

Apotheciis sparsis, atronitidis, subrotundatis usque ellipticis, subcuticularibus,  $330\text{--}790 \times 260\text{--}300 \mu$ , carbonaceis in regione rimae, in regione fortiter afflata in medio basis, et in margine; fissuris latis, longitudinalibus, non periphysibus ornatis aperientibus; paraphysibus filiformibus, simplicibus, ascos excedentibus, epithecium vitellinum,  $15 \mu$  densum formantibus,  $120\text{--}165 \times 1\text{--}1.5 \mu$ ; ascis cylindricis,  $107\text{--}157 \times 5\text{--}6.5 \mu$ ; ascosporis cylindricis,  $60\text{--}100 \times .75\text{--}1 \mu$ , cum matrice gelatinosa inconspicua.

Type specimen: B. H. Davis, May 24, 1931; type locality: Strondsberg, Pennsylvania; host: *Leucothoë Catesbaei* (Walt.) Gray; specimens examined: the type (communicated by R. P. White) and another collected by R. P. White, Princeton, New Jersey, May, 1929.

The specimens cited above were reported by White (16) as *Lophodermium*. On species of *Leucothoë* three fungi with elongated ascomata have been reported, namely, *Hypoderma variegatum* (Berk. & Curt.) Duby, *Clithris Andromedae* (Schw.) Ellis & Ev., and *Lophodermellina hysterioides* (Pers.) von H. Both *H. variegatum* and *C. Andromedae* are described, and the latter is illustrated, by Duby (5). Both are described also by Ellis and Everhart (6). These descriptions and illustrations indicate clearly, as does also comparison with No. 155 of Ellis' North American Fungi, that the present fungus is essentially different in the size and shape of its asci and ascospores, as well as with respect to other important characters. It is probable that the report of *L. hysterioides* on this host is the result of an erroneous identification.

***Clithris Rosae* (Teng) comb. nov. (FIG. 2).**

*Lophodermium Rosae* Teng, *Sinensia* 4: 138. 1933.

Apothecia scattered but numerous in well defined creamy white areas on stems, dull black, without directional orientation, discrete or sometimes confluent end-to-end, narrowly oval to elongate or linear, with bluntly rounded ends,  $650\text{--}1800 \times 200\text{--}400 \mu$ , with thick walls heavily carbonized throughout, cover brittle and tending to break away irregularly, opening by a longitudinal slit nearly as long as the apothecium; paraphyses lacking. Paraphyses abundant, hyaline, filiform, simple, straight or flexuous, of uniform

diameter, exceeding the asci and crushed, bent, and intertwined above them to form a dull white to yellowish epithecium  $15\text{--}25\ \mu$  thick,  $90\text{--}150 \times 1.5\text{--}2\ \mu$ , apparently without a gelatinous matrix. Asci cylindrical, straight or somewhat flexuous, bluntly and symmetrically rounded at the tips, tapered near the base to a pronounced foot,  $85\text{--}140 \times 5\text{--}7\ \mu$ , 8-spored. Ascospores hyaline, filiform, straight, flexuous, or rarely coiled in the ascus, fasciculate in pairs,  $35\text{--}70 \times 1.5\text{--}2\ \mu$ , without a gelatinous matrix.

Type specimen: C. I. Shen, No. 390 (No. 76 in the Metropolitan Museum, Academia Sinica, Nanking, China); type locality: Hengshan, Hunan province, China; host: *Rosa* sp., on dead twigs; specimen examined: part of the type, labeled "co-type" by Dr. Teng; illustrations: Teng, *Sinensia* 4: 144, fig. 15. 1933.

Teng has pointed out (*l. c.*) that this fungus differs from *Lophodermellina hysteroioides* (Pers.) von H. in its strictly ramicole habit and in characteristics of the paraphyses, asci, and ascospores. It is also subepidermal in insertion and does not possess the aliform plates characteristic of *L. hysteroioides*. Sections show, also, that it is not referable to *Lophodermium*. As has been pointed out by Nannfeldt (11) and by Tehon (15), the hysterothecia of this genus open in a manner much resembling that of the Sphaeriales, and their elongated ostioles are lined with paraphyses. The opening in this Chinese fungus is a purely mechanical split, the edges of which bear no paraphyses; no labia are present; and there is no division of its apothecium into base and cover plates.

#### ***Bifusella Vaccinii* sp. nov.**

*Bifusella Vaccinii* (Carmichael) Tehon, Illinois Biol. Monographs 32 (51): 117. 1935. In part.

Hysterothecia appearing golden-brown, scattered or crowded, often oriented parallel with the stem axis, on dead portions of stems, broadly elliptical with somewhat truncated ends,  $450\text{--}675\ \mu$  long,  $325\text{--}375\ \mu$  wide, subepidermal. Labia of the slit indefinite, somewhat thickened and carbonized in the middle,  $\frac{2}{3}\text{--}\frac{3}{4}$  the length of the hysterothecium. Base a thin plate of loose pseudoparenchyma browned at the cell unions but scarcely distinguishable from the thin hyaline plectenchyma from which the hymenium arises; cover a compact, brown translucent plectenchyma underlaid to varying thicknesses by brown pseudoparenchyma. Paraphyses filamentous, hyaline, straight or flexuous, variously bent or crushed

at the tips which are gelatinously fused into a thin white epithecium, 90–115  $\mu$  long, about 1  $\mu$  wide. Asci clavate, truncately rounded above, tapered to a long, fine stipe, 85–100  $\mu$  long, 15–20  $\mu$  wide, 4-spored. Ascospores hyaline, nonseptate, bifusiform, 55–62  $\mu$  long, 4–5  $\mu$  wide, incased in a conspicuous, hyaline gelatinous matrix, 2.5–3  $\mu$  thick.

*Hysterothecii aureis-brunneis*, sparsis aut confertis, late ellipticis et utrimque truncatis, subepidermalibus, 450–675  $\times$  325–375  $\mu$ ; labiis rimae non bene definitis, in medio carbonaceis; basi pseudoparenchymatica; tegmine pseudoparenchymate compacto, brunneo, translucente; paraphysibus filiformibus, hyalinis, epithecium album formantibus, 90–115  $\times$  1  $\mu$ ; ascis clavatis, supra truncate rotundatis, longis pedicellatis, 85–100  $\times$  15–20  $\mu$ , quadrisporis; ascosporis bifusiformibus, hyalinis, continuis, 55–62  $\times$  4–5  $\mu$ , cum matrice gelatinosa hyalina, conspicua, 2.5–3  $\mu$  densa.

Type specimen: Reliquiae Farlowiana No. 46; type locality: New Hampshire; host: *Vaccinium pennsylvanicum* Lam.; illustration: Tehon, Ill. Biol. Monog. 32 (51): 118, fig. 1. 1935.

*Bifusella*, according to von Höhnelt (7), is subcuticular and stromatic. This fungus possesses neither of these characters. But Darker (3) has pointed out that it is the only hypodermataceous genus to which bifusiform-spored fungi can be assigned. Boughey (1) has determined, by examining the type specimens in the Kew Herbarium, that *Hysterium Vaccinii* Carm. is a *Gloniopsis* and that *Hysterium cladophyllum* Lév., as represented by Mougeot and Nestler's Stirp. Crypt. No. 1243, has filiform spores. This, he states correctly, leaves *Bifusella Vaccinii* (Carm.) Teh., an untenable binomial for either *Hysterium Vaccinii* or *H. cladophyllum*. It is, however, the only tenable name for the American bifusiform-spored material on *Vaccinium* and is here formally proposed in that sense.

### **Hypoderma Apocyni** sp. nov. (FIG. 3).

*Hysterothecia* shining black, discrete, oriented parallel to the stem axis in yellow to cinereous, unlimited spots of small to large extent, narrowly elliptical to fusoid in outline, with sharply rounded to acute ends, 1–2 mm. (1100–1975  $\mu$ )  $\times$  270–420  $\mu$ , subcuticular. Labia indistinct and merging with the cover, carbonized along the length of the ostiole, narrow at the ends, broader in the middle, conforming in outline to the hysterothecial shape, up to 90  $\mu$  wide, and 40  $\mu$  thick, lined inwardly by a dense mass of bright yellow, clavately expanded, gelatinously agglutinated, persistent periphyses

7-15  $\times$  3-4  $\mu$ . Cover well arched, carbonized only in the labia, elsewhere brown and more or less translucent, consisting of an outer plate of radiately disposed aliform hyphae thickened toward the middle by the apposition, below, of 1 to several layers of brown pseudoparenchyma, separate from the base at the margins. Basal layer a brown, translucent, concave plate of radially disposed aliform hyphae, occasionally thickened by the apposition, above, of small patches of brown pseudoparenchyma; this overlaid by a plectenchyma 8-15  $\mu$  thick of fine, closely interwoven, hyaline hyphae from which the hymenium arises. Paraphyses abundant, filiform, flexuous, much exceeding the asci, irregularly uncinata, coiled, or spiraled toward the unexpanded tips, without apparent gelatinization and not forming a compact epithecium, 0.75-1  $\mu$  wide. Asci narrowly clavate and long stalked, bluntly rounded above, 80-100  $\times$  8-12  $\mu$ , 8-spored. Ascospores elongated, straight or curved, obtuse distally, acute below, 1-septate, not constricted, fasciculate and in pairs, 21-28  $\times$  2.5-3.5  $\mu$ , without a gelatinous matrix.

Hysterothecii atronitidis, discretis, anguste ellipticis usque fusoides, in apicibus acute rotundatis, subcuticularibus, 1-2 mm.  $\times$  270-420  $\mu$ ; labiis ostioli carbonaceis, usque 90  $\mu$  latis et 40  $\mu$  densis, periphysibus flavis clavatis, 7-15  $\times$  3-4  $\mu$  ornatis; tegmine et basi radiantibus et ex hyphis aliformibus compositis; paraphysibus filiformibus, ascos multo excedentibus sed epithecium compactum non formantibus; ascis clavatis, longis pedicellatis, 80-100  $\times$  8-12  $\mu$ ; ascosporis rectis vel curvatis, supra obtusis, basim acutis, 1-septatis, 21-28  $\times$  2.5-3.5  $\mu$ .

Type specimen: J. R. Hansbrough, No. 1766, August 27, 1935; type locality: Pine Plains, New York; host: *Apocynum medium* Greene, on dead stems.

No species of *Hypoderma* appears to have been reported previously on any member of the Apocynaceae in America. *H. commune* (Fries) Duby as commonly reported on dead stems of various herbs is undoubtedly a "catch-all" species into which many distinct forms have been thrown as a result of the imperfect definitions promulgated by Duby (5) and Rehm (13); but considering even the wide and inclusive range of forms these authors have suggested for it, this fungus is distinct from it in size of ascus and ascospore as well as hysterothecial characters.

***Hypoderma Caryae* sp. nov. (FIG. 1).**

Hysterothecia shining black, scattered, discrete, oriented parallel with the petiole axis in ashen to white, unlimited spots of variable,

often large, extent, narrowly elliptical with bluntly rounded ends,  $800-1500 \times 270-400 \mu$ , subcuticular. Labia indistinct, merging gradually into the hysterothecial cover, up to  $45 \mu$  thick at the ostiole, carbonized and opaque to a width of  $65 \mu$ , never extroverted, lined with a loose mass of hyaline to cream-colored, clavately expanded, gelatinously agglutinated, persistent periphyses  $5-10 \times 2-2.5 \mu$ . Cover rather flat, carbonized in the labia, elsewhere brown and more or less translucent, consisting of an outer plate of chitinized, radiately disposed, aliform mycelium and 2 or more layers of underlying brown pseudoparenchyma. Basal layer a concave plate 1 cell thick of brown, translucent, radiately disposed aliform hyphae overlaid to a depth of  $8-10 \mu$  by a hyaline plectenchyma of very fine hyphae from which the hymenium arises; base and cover closely applied to each other at the margins to a width of  $60-80 \mu$ . Paraphyses abundant, hyaline, flexuous, simple, exceeding the asci and often somewhat expanded or flattened above them into an imperfect, shining white epithecium,  $75-120 \mu$  long,  $.75-1.25 \mu$  wide. Asci clavate and long stalked, rounded above,  $74-100 \mu$  long,  $8-11.5 \mu$  wide, 8-spored. Ascospores hyaline, elongated, fusiform, non-septate in the ascus, 1-septate after emission, curved, bluntly rounded distally, tapered and subacute at the base, more or less fasciculate and in pairs,  $18-26 \times 2.5-3.6 \mu$ , without an apparent gelatinous matrix.

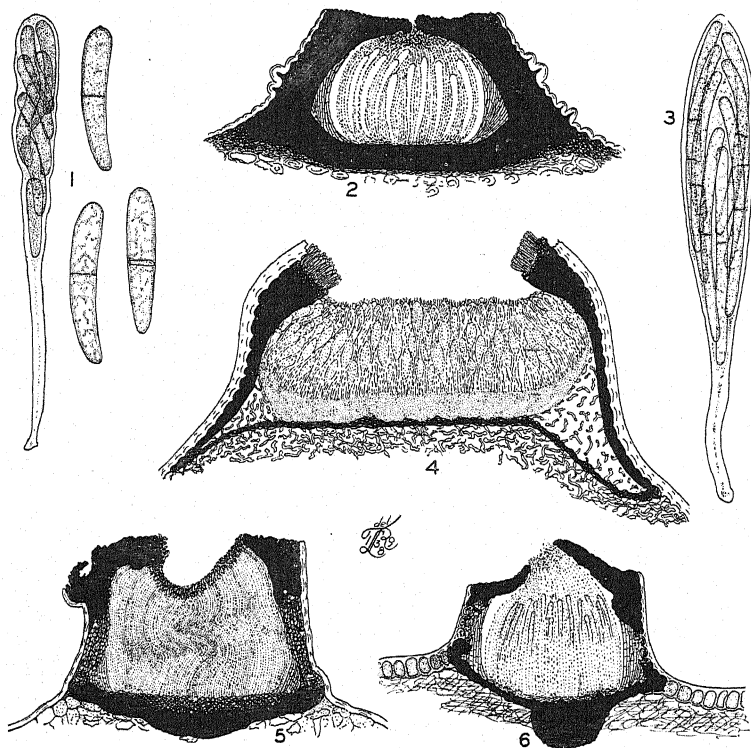
Hysterotheciis sparsis, atronitidis, discretis, anguste ellipticis et utrimque rotundatis, subcuticularibus,  $800-1500 \times 270-400 \mu$ ; labiis ostioli carbonaceis,  $65 \mu$  latis,  $45 \mu$  densis, periphysibus hyalinis usque cremeis, clavatis,  $5-10 \times 2-2.5 \mu$  ornatis; tegminibus planioribus, ipsis et basibus radiantibus, ex hyphis aliformibus compositis, in margine per  $60-80 \mu$  disculum formantibus; paraphysibus hyalinis, flexuosis, supra ascos epithecium lucidum album formantibus,  $75-120 \times .75-1.25 \mu$ ; ascis clavatis, longis pedicellatis,  $74-100 \times 8-11.5 \mu$ ; ascosporis hyalinis, elongatis, fusiformibus, curvis, basim subacutis, continuis in ascis, postea 1-septatis,  $18-26 \times 2.5-3.6 \mu$ .

Type specimen: H. G. Eno, November 7, 1935 (communicated by J. R. Hansbrough, No. 1772); type locality: Harvard Forest, Hamilton, Massachusetts; host: *Carya glabra* (Mill.) Spach., on fallen petioles.

The subcuticular insertion ascribed to the hysterothecia of this species is determinable with difficulty. The hysterothecial cover appears directly applied to the cuticle; but the internal mycelium brings about complete dissolution of the epidermal cells and underlying tissues, except strands of sclerenchyma; and, except occasionally at the hysterothecial margins, no cell fragments remain by which the insertion can be determined with certainty. Never-



theless, the close adherence of the cover to the cuticle, the clearcut aliform structure of both the cover and base, and the close application of the margins of the cover and base to each other indicate clearly a subcuticular development.



FIGS. 1-6. Morphology in *Hypoderma* and *Clithris*.

The fact that the ascospores are non-septate until after extrusion from the ascus might seem to justify placing the fungus in *Hypodermella*; but on the basis of the type species, *H. Laricis* v. Tubeuf, and of other pinicolous species clearly congeneric, Darker (3) has more clearly defined the genus as including only distinctly clavate spores. He has, however, segregated in his genus *Elytroderma* a pinicolous species, *Hypoderma deformans* Weir, which this hickory fungus resembles in spore shape, in part because its ascospores become bicellular in maturity; but the

intended taxonomic distinction between it and *Hypoderma Rubi* (Pers. ex Fries) De Not., type species of *Hypoderma*, is not clear, since the ascospores of the latter also become bicellular.

#### HYPODERMA EQUISETI Ellis & Ev.

What presumably is to be regarded as part of the type specimen of this species, Ellis and Everhart's Fungi Columbiani No. 1335, on dead stems of *Equisetum hyemale* L. from Rooks County, Kansas, proves in the copy available to me to be sterile and in such poor condition as to be incapable of any kind of identification. Sections reveal disorganized stromatic fungus tissue beneath the epidermal cells but give no key to structure.

#### HYPODERMA ERICAE von Tubeuf.

Two specimens have been available to me, both in Otto Jaap's Fungi selecti exsiccati. Number 707, on *Erica verticillata* Forsk., from Dalmatia, bears no asci. Sections reveal a black stromatic structure, sphaerical in cross section, without differentiation into cover and base, that occupies most of the mesophyl, extends into the lumina of the outer (upper) epidermal cells and contains nothing but a small sphaerical body, possibly an internal parasite. Some of the latter appear, in the sections, to bear immature asci; but no mature asci were found in crushed preparations. None of the customary features of an hysterothecium can be discerned.

Number 558, on *Erica carnea* L., from Südtirol, is also sterile and exhibits the same suggestive evidence of internal parasitization.

#### *Hypoderma Eupatorii* sp. nov.

Hysterothecia abundant, shining-black, spindle-shaped, acute at both ends, straight or somewhat curved, oriented parallel to the stem axis in very extensive, unlimited stramineous areas, discrete or rarely contiguous or fused laterally or terminally, 1.2 to 2.3 mm. long, 415–520  $\mu$  wide, subcuticular. Labia prominent, arched, spreading uniformly, up to 65  $\mu$  thick, heavily carbonized and often breaking away, uniformly 65–80  $\mu$  wide, nearly as long as the hysterothecium, bordered inwardly by a mass of gelatinously agglutinated, bright greenish, clavately expanded periphyses 12–15  $\times$  1.5–3.5  $\mu$ , that are persistent and rufescent in age. Basal layer a thin plate of irregular, radiately disposed prosenchyma, dilute

brown and translucent, definitely limited marginally by a series of aliform terminal cells, overlaid to a depth of  $8-17\ \mu$  by a closely interwoven plectenchyma of fine hyaline hyphae, from which the hymenium arises. Cover a dark, usually carbonized but sometimes translucent brown, well-arched plate of pseudoparenchyma extending marginally somewhat beyond the base and with aliform terminal cells intermixed with straggling fringe-like cylindrical hyphae of varying lengths at the margin. Paraphyses hyaline, filiform, straight or curved, equalling to much exceeding the asci, variously crumpled at the tips but not gelatinously encased or agglutinated, up to  $124\ \mu$  long,  $1-1.5\ \mu$  wide. Asci clavate, tapered below to a long, thin stipe, expanded basally into a small globose foot,  $74-104 \times 8-12\ \mu$ , 8-spored. Ascospores hyaline, non-septate in the ascus, cylindrical to spindle-shaped, rounded above, acute below, arranged in pairs in the terminal half of the ascus,  $26-33 \times 3-3.5\ \mu$ , without evident gelatinous envelopes.

Hysterothecii atronitidis, discretis, fusiformibus, utrimque acutis,  $1.2-2.3\ \text{mm.} \times 415-520\ \mu$ , subcuticularibus; labiis ostioli fornicatis, fortiter carbonaceis,  $65-80\ \mu$  latis, usque  $65\ \mu$  densis, periphysibus viridibus, clavatis,  $12-15 \times 1.5-3.5\ \mu$ , persistentibus et in aetate rufescentibus ornatis; tegminibus non radiantibus sed ad marginem cum cellulis terminalibus aliformibus; basibus radiantibus; paraphysibus hyalinis, filiformibus, ascos aequantibus aut excedentibus, usque  $124 \times 1-1.5\ \mu$ ; ascis clavatis,  $74-104 \times 8-12\ \mu$ ; ascosporis hyalinis, non septatis, cylindricis, basim acutis  $26-33 \times 3-3.5\ \mu$ .

Type specimen: Ellis, North America Fungi, No 464 (as *Hypoderma commune* (Fries) Duby); type locality: Westchester, Pennsylvania; host: *Eupatorium purpureum* L., on dead stems.

### *Hypoderma longissima* sp. nov.

Hysterothecia shining black, in light gray to stramineous, unlimited, often extensive areas, oriented parallel to the stem axis, straight or rarely somewhat curved, discrete or rarely united end to end, narrowly elliptical to linear with acutely rounded ends,  $1.2-4\ \text{mm.} (1248-4024\ \mu) \times 375-540\ \mu$ , subcuticular. Labia prominent, extroverted in age, heavily carbonized and opaque, up to  $65\ \mu$  wide and  $40\ \mu$  thick, lined on the margins by a compact mass of persistent, gelatinously agglutinated, clavately expanded, golden periphyses  $8-15\ \mu$  long (up to  $50\ \mu$  long at the ends)  $\times 2-3\ \mu$  wide. Cover highly arched, carbonized above the hymenium but at the margin translucent, flattened, and closely applied to the base so as to form a flange-like border  $40-70\ \mu$  wide, consisting of an outer plate of chitinized, radiately disposed, aliform mycelium thickened above the hymenium by 1 to several cells of carbonized pseudo-

parenchyma. Base a concave, translucent plate 1 cell thick, flattened at the margin with the cover, composed of radiately disposed aliform hyphae; this overlaid in the hollowed area by a cushion  $5-10\ \mu$  thick of very fine, hyaline, closely interwoven hyphae from which the hymenium arises. Paraphyses abundant, hyaline, filiform, straight or flexuous, exceeding the asci and variously bent and crushed above them to form a loose, indefinite, white epithecium, up to  $110\ \mu$  long,  $1-1.5\ \mu$  in diameter, without apical gelatinization. Asci narrowly clavate, short- or long-stalked, acutely rounded at the apex,  $65-100 \times 8-12\ \mu$ , 8-spored. Ascospores hyaline, non-septate in the ascus, fusiform, obtuse distally, sub-acute at the base, usually fasciculate and in pairs,  $18-24 \times 2-3\ \mu$ , without a gelatinous matrix.

*Hysterothecii atronitidis*, discretis, anguste ellipticis usque linearibus, ad apices acute rotundatis, subcuticularibus,  $1.2-4\ \text{mm.} \times 375-540\ \mu$ ; labiis ostioli fortiter carbonaceis, usque  $65\ \mu$  latis et  $40\ \mu$  densis, periphysibus aureis clavatis,  $8-15 \times 2-3\ \mu$  ornatis; tegminibus et basibus radiantibus, ex hyphis aliformibus compositis, ad marginem disculum  $40-70\ \mu$  latum formantibus; paraphysibus hyalinis, rectis, ascos excedentibus et epithecium album formantibus, usque  $110 \times 1-1.5\ \mu$ ; ascis anguste clavatis, ad apicem acute rotundatis,  $65-100 \times 8-12\ \mu$ ; ascosporis hyalinis, fusiformibus, basim subacutis, non septatis,  $18-24 \times 2-3\ \mu$ .

Type specimen: Wilson and Seaver, Ascomycetes and Lower Fungi, No. 9; type locality: Bronx, New York City, New York; host: Herbaceous stems, undetermined.

This material, collected by Seaver in the winter of 1906 and distributed as *Hypoderma commune* (Fries) Duby, should stand as a distinct species because of the size and shape of its hysterothecia, because of the strikingly developed and distinctive hysterothecial border, and because of hymenial distinctions.

### ***Hypoderma pacificensis* sp. nov.**

Hysterothecia shining black, in tan to cinereous brown-limited spots of small to large extent, oriented parallel to the petiole axis, oval-fusiform to linear, discrete or rarely joined end to end,  $1-3\ \text{mm.} (1102-2912\ \mu) \times 400-625\ \mu$ , subcuticular. Labia indistinct, carbonized and opaque, tapered at the ends, up to  $100\ \mu$  wide and  $80\ \mu$  thick, lined inwardly by a compact mass of bright yellow, clavately expanded, gelatinously agglutinated periphyses rather uniformly  $12-15\ \mu$  long by  $2.5-3\ \mu$  wide. Cover well arched, carbonized and thickened only in the labia, elsewhere translucent brown, extending near the ends of the hysterothecia as a flat plate

closely applied to and equalling or exceeding the base, composed of chitinized, radiately disposed, aliform hyphae and thickened near the labia only by 1 or 2 layers of brown, translucent pseudoparenchyma. Basal layer a concave plate of translucent, brown, radiately disposed aliform hyphae thickened along the center by 1 or 2 layers of brown, translucent pseudoparenchyma; this overlaid to a depth of  $10-15\mu$  by a cushion of fine, hyaline, closely interwoven hyphae from which the hymenium arises. Paraphyses hyaline, filiform, flexuous, shorter than, equalling, or somewhat exceeding the asci, the longest curved, uncinat, or coiled at the tip to form a thin, loose epithecium,  $60-100\mu$  long,  $0.7-1.25\mu$  in diameter. Asci clavate, long- and slender-stalked, acutely rounded above, often asymmetrical in the saccate portion,  $75-125$ , chiefly  $90-100 \times 7.5-12$ , chiefly  $8-10\mu$ , 8-spored. Ascospores hyaline, non-septate, fusiform, curved, obtusely rounded distally, tapered and subacute basally, closely fasciculate and arranged in pairs,  $20-28 \times 2.5-3.5\mu$ , without a gelatinous matrix.

Hysterothecii atronitidis, discretis, ovalo-fusiformibus usque linearibus, subcuticularibus,  $1-3\text{ mm.} \times 400-625\mu$ ; labiis ostioli carbonaceis, usque  $100\mu$  latis et  $80\mu$  densis, periphysibus clavatis, vitellinis,  $12-15 \times 2.5-3\mu$  ornatis; tegminibus et basibus radiantibus, ex hyphis aliformibus compositis; paraphysibus hyalinis, filiformibus, ascos non aequantibus usque excedentibus et epithecium formantibus,  $60-100 \times 0.7-1.25\mu$ ; ascis clavatis, supra acute rotundatis,  $75-125 \times 8-10\mu$ ; ascosporis hyalinis, fusiformibus, curvis, basim subacutis, non septatis,  $20-28 \times 2.5-3.5\mu$ .

Type specimen: J. S. Boyce, No. 842, July 21, 1921; type locality: Marcola, Lane County, Oregon; host: *Acer macrophyllum* Pursh, on petioles of fallen leaves; distribution: known only from the type locality (Boyce, specimen; Martin (9)).

This Pacific material differs strikingly from the *Hypoderma rufilabrum* on *Acer* in the Eastern States.

*HYPODERMA RUFILABRUM* (Berk. & Curt.) Duby (FIG. 4).

*Hysterium rufilabrum* Berk. & Curt. Grevillea 4: 12. 1875.

*Hypoderma rufilabrum* Duby, Mém. Soc. Phys. Hist. Nat. Genève 16: 52. pl. 2, f. 21, a, b, c, d. 1861.

Hysterothecia shining black, scattered without definite orientation in cream to cinereous, sunken, unlimited spots of small to large extent on twigs, discrete or variously united end to end or laterally, appearing striated, narrowly elliptical to linear with rounded or pointed ends and very irregular margins,  $500-750\mu$

wide, 800  $\mu$ –3 mm. long, or much longer when united, doubtfully subcuticular. Labia prominent and distinct, eventually extroverted, heavily carbonized and opaque, 65–130  $\mu$  wide, up to 60  $\mu$  thick, lined inwardly by a closely compacted mass of slender, clavately expanded, gelatinously agglutinated, bright orange, in age rufescent, long-persistent periphyses up to 25  $\mu$  long and 2.5–3  $\mu$  wide. Cover much arched or in maturity with the 2 halves nearly vertical to the base, carbonized in the labia only, elsewhere more or less translucent, consisting of an outer plate of radiately disposed brown, aliform hyphae thickened by the apposition below of 2 to several layers of brown pseudoparenchyma, very irregular at the margin and fringed by numerous loose, brown hyphal tips. Base a convex plate of radiately disposed, brown, translucent aliform hyphae thickened by apposition, above, of 1 to 3 layers of brown pseudoparenchyma; this overlaid to a depth of 20–35  $\mu$  by a closely and densely interwoven layer of fine, hyaline hyphae from which the hymenium arises. Paraphyses abundant, filiform, hyaline, equaling or slightly exceeding the asci, curved, uncinatate or variously coiled or spiraled at the tips and forming a very thin, loose, shining-white epithecium, 80–150  $\mu$  long, .75–1  $\mu$  wide, without evident gelatinization. Asci clavate, long-stalked, rounded to subacute above, 75–145, chiefly 105–115  $\mu$  long, 12–18  $\mu$  wide, 8-spored. Ascospores hyaline, fusiform, curved, bluntly rounded above, tapered below and subacute, non-septate in the ascus, bicellular after emission, 20–25  $\times$  3.5–5.0  $\mu$ , without an apparent gelatinous matrix.

Type specimens: in the Kew herbarium, according to Masee (10); also in the Université de Strasbourg, Institute Botanique et Jardin Botanique, labeled "*Hysterium ruflabrum*, B. & C. in *Acer striato*. Nova Anglia, M. Curtis 1857." The latter, with its accompanying slide and drawings, is the material described and figured by Duby (5). Type locality: Uncertain. According to Berkeley (*l. c.*), South Carolina; according to Duby (5, p. 53), New England; according to Ellis and Everhart (6, p. 712), South Carolina; according to the type specimens, New England. Hosts and distribution: *Acer*, possibly *pennsylvanicum* L., the *Acer striatum* or "striped maple" of Berkeley and Curtis (*l. c.*), Duby (5), Masee (10), and Ellis and Everhart (6): New England (Duby (5) and the types); North Carolina (Ellis and Everhart (6), citing Ravenel). *A. spicatum* Lam.: New Hampshire (Farlow, *exs.*; Hansbrough, specimen); New York (Dearness and

House (4); House, specimen; Jackson (8); Peck (12); and Peck, specimen). Specimens examined: Duby's type; *Reliquiae Farlowianae* 127; J. R. Hansbrough, No. 1598, Cherry Mt., Carroll, N. H., July 25, 1932; H. D. House, Newcomb, Essex Co., N. Y., June 8, 1922 and June 20, 1923; C. H. Peck, Helderberg Mts., without date or number.

The hysterothecia of this fungus are, as noted by Massee (10), often oriented parallel with the host axis on small twigs; but on larger twigs they either are without orientation or stand at right angles to the axis. Ellis and Everhart (6) quote the ascospore length as  $15\ \mu$ , evidently a translation of the .0006 measurement given by Berkeley (*l. c.*); and Massee (10) gives their measurements as  $14\text{--}17 \times 1.5\ \mu$ . Neither in the Duby specimen nor in any other have I found spores so small.

#### EPIDERMELLA COMMUNIS (Fries) Teh.

Material on petioles of *Cassia*, in H. W. Ravenel's *Fungi Americani Exsiccati* No. 323, from Aiken, South Carolina, has in the copy available to me only sterile hysterothecia. These have the following characterization: shining black, oriented parallel to the axis of the petiole in unlimited sunken yellow to cinereous areas of variable, often large, extent, discrete or confluent end to end in long lines, straight or rarely curved, fusiform to linear with acutely rounded ends, 1–2 mm. ( $1248\text{--}2080\ \mu$ ) long,  $375\text{--}686\ \mu$  wide, subcuticular. Labia prominent, heavily carbonized, extroverted, up to  $55\ \mu$  wide, lined inwardly by a persistent mass of bright orange, rufescent, gelatinously agglutinated, clavately expanded periphyses up to  $10\ \mu$  long by  $2.5\text{--}3\ \mu$  wide. Cover a deltidoidly convex, translucent plate of red-brown, radiately disposed aliform mycelium thickened and carbonized only in the labia. Base a gray-brown, translucent, concave plate of aliform mycelium slightly less extensive longitudinally than the cover. The general appearance is not that of *E. communis*.

#### *Epidermella Hansbroughi* sp. nov.

Hysterothecia dull to shiny black, numerous, scattered in well marked but not delimited stramineous areas of small to large ex-

tent on stems, for the most part oriented parallel to the stem axis, discrete or rarely confluent end to end, oval to oblong with bluntly rounded ends,  $725\text{--}1165\ \mu$  long,  $270\text{--}525\ \mu$  wide, subcuticular. Labia absent as distinct structures, and the slit only doubtfully lined with periphyses. Basal layer a plate 1 cell thick, composed of loosely and radially disposed brown, clearly translucent, aliform hyphae; this overlaid to a depth of  $10\text{--}25\ \mu$  by a closely woven hyaline plectenchyma composed of very fine hyphae. Cover well arched, without carbonization, translucent, outermost layer radial in disposition and aliform in structure, erose to minutely fimbriate at the margin, coextensive with the basal plate, rupturing longitudinally at maturity,  $20\text{--}35\ \mu$  thick. Paraphyses hyaline, filamentous, straight or flexuous, often hamate or unciniate, abruptly swollen apically so as to terminate in a spherical enlargement, or often with several such enlargements forming a toruloid chain, not gelatinously agglutinated but exceeding the asci and thereby forming a shining white epithecium,  $65\text{--}90\ \mu$  long,  $.75\text{--}1\ \mu$  wide. Asci long-fusiform, asymmetrically subacute at the tips, tapered from a little below the tips to long, slender stipes,  $55\text{--}75\ \mu$  long,  $5\text{--}6\ \mu$  wide, 8-spored. Ascospores hyaline, acicular, straight or slightly twisted within the ascus, fasciculate in the expanded distal half of the ascus and also arranged in pairs, blunt distally and tapered to an acuminate base,  $20\text{--}35\ \mu$  long,  $1\text{--}1.5\ \mu$  wide, cased in a hyaline, very thin, inconspicuous gelatinous matrix.

Hysterotheciis ateribus usque atronitidis, discretis, ovalibus usque oblongis, ad apices rotundatis, subcuticularibus,  $725\text{--}1165 \times 270\text{--}525\ \mu$ ; labiis et periphysibus ostioli dubiis; tegmine non carbonacea, fortiter fornicata, ipso et basi radiantibus et ex hyphis aliformibus compositis, ad marginem minute fimbriatis; paraphysibus hyalinis, filiformibus, in apicibus bullatis et saepe bullulis toruloideis, ascos excedentibus, epithecium album formantibus,  $65\text{--}90 \times .75\text{--}1\ \mu$ ; ascis longis fusiformibus,  $55\text{--}75 \times 5\text{--}6\ \mu$ ; ascosporis hyalinis, acicularibus, supra obtusis, basim acuminatis,  $20\text{--}35 \times 1\text{--}1.5\ \mu$ , cum matrice gelatinosa inconspicua.

Type specimen: J. R. Hansbrough, No. 3069, July 8, 1937; type locality: Everett Orchards, on the east slope of Mt. Anthony, Bennington, Vermont; host: *Rubus idaeus* L., var. *aculeatissimus* (Mey.) Reg. & Til., on dead stems.

Dr. J. R. Hansbrough, by whom the specimen was collected and communicated, records that the fungus is common locally [at the type locality] on stems of its host, that it invades them particularly near the tips, and that it is apparently entirely saprophytic.



The allocation of this new fungus in *Epidermella* is made with hesitation. It certainly is different from *Dermascia rubiicola* (Earle) Teh. and can in no way be confused with the form of *Hypoderma virgultorum* (Pers.) D. C. which Chevallier (2) segregated under the name *Lophodermium Rubi*. As noted in the description, the hysterothecium is situated subcuticularly; and both the basal plate and the cover plate are composed of aliform mycelium and are radiate with respect to the disposition of their component hyphae. However, provision made for the discharge of spores is dubiously that of the Hypodermataceae. If any primordium for an ostiole is laid down during the development of the cover plate, it has not been apparent in any of my sections; and neither labia nor periphyses have been found in matured material.

LOPHODERMINA RHODODENDRI (Schw.) Teh.

The habit of this species is to be extended to include attack on stems. A specimen from J. R. Hansbrough (No. 420), collected at Rhododendron, Oregon, in March, 1931, is on stems of *Rhododendron californicum* Hook. Dr. Hansbrough states that it is apparently parasitic and causes dying back of the attacked twigs. In this material the ascospores differ from those hitherto observed in leaf inhabiting material in that they taper basally to needle-like points and resemble in this respect certain very long-spored species of *Hypodermella*, for example, *H. punctata* Darker and *H. Abietis-concoloris* (Mayr) Dearn.

*Lophodermium Danthoniae* sp. nov.

Hysterothecia black, scattered in unlimited stramineous areas along the length of leaves and sheaths, oriented parallel with and situated between the veins, narrowly to broadly elliptical with rounded to inconspicuously apiculate ends,  $330-400 \times 195-325 \mu$ , subepidermal. Labia prominent, heavily carbonized, eventually completely extroverted, about  $4/5$  the hysterothecial length,  $20-35 \mu$  wide, somewhat erose and lined inwardly by a mass of persistent, clavately expanded, hyaline, gelatinously agglutinated periphyses  $5-10 \times 1-1.5 \mu$ . Cover well arched, thin, brown, more or less translucent except in the carbonized labia, its outer plate of aliformly terminated hyphae underlaid by 1 or 2 layers of brown pseudoparenchyma. Basal layer a plate of brown, translucent,

radially disposed, aliformly terminated, irregular hyphae, occasionally thickened by 1 or 2 layers of brown pseudoparenchyma; this overlaid to a depth of  $5-10\ \mu$  by a closely interwoven plectenchyma of fine, hyaline hyphae from which the hymenium arises. Paraphyses hyaline, filamentous, straight or flexuous, expanded toward the tips, becoming uncinat, bent, or crushed by pressure and gelatinously agglutinated above the asci into a shining white epithecium  $3.5-5\ \mu$  thick, up to  $75\ \mu$  long,  $1-1.5\ \mu$  wide. Asci cylindrical-clavate, asymmetrically acute above, widest above the middle, tapered downward and abruptly narrowed near the base to a rounded foot,  $45-65 \times 6-7.5\ \mu$ , 8-spored. Ascospores hyaline, filiform, non-septate, of uniform diameter, fasciculate and arranged in pairs, straight or somewhat twisted with the ascus,  $35-45 \times 1-1.5\ \mu$ , gelatinous matrix inconspicuous.

*Hysterothecis nigris*, sparsis, anguste usque late ellipticis, utrinque rotundatis vel apiculatis, subepidermalibus,  $330-400 \times 195-325\ \mu$ ; labiis ostioli fortiter carbonaceis,  $20-35\ \mu$  latis, periphysibus hyalinis, clavatis,  $5-10 \times 1-1.5\ \mu$  ornatis, tegmine ex hyphis aliformibus, basi ex hyphis radiantibus et aliformibus composita; paraphysibus hyalinis, filiformibus, in apicibus inflatis, ascos excedentibus, apothecium album,  $3.5-5\ \mu$  densum formantibus, usque  $75 \times 1-1.5\ \mu$ ; ascis cylindro-clavatis,  $45-65 \times 6-7.5\ \mu$ ; ascosporis hyalinis  $35-45 \times 1-1.5\ \mu$ , cum matrice gelatinosa inconspicua.

Type specimen: J. J. Davis, without number, dated August 11, 1934, in the herbarium of the University of Wisconsin; type locality: Brule, Wisconsin; host: *Danthonia spicata* (L.) Beauv., on dead leaves; specimens examined: the type and G. H. Boewe, Carbondale, Illinois, April 28, 1938, Accession No. 27027 in the Illinois Natural History Survey Mycological Collection.

This species is very closely allied with *L. Airarum* (Fries) Hiltner, from which it is distinguished by its smaller hysterothecia, shorter, narrower asci, and shorter ascospores. The level at which its hysterothecia are inserted in the host is determinable with difficulty, as often is true of other graminicolous species, because it completely disorganizes the host tissues, including epidermal cells adjacent to the hysterothecial margins, and leaves definitely intact only the cuticle. No imperfect form is present in either of the specimens.

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## EXPLANATION OF FIGURES

FIGS. 1-6. 1, *Hypoderma Caryae*, ascus and three septate ascospores; 2, *Clithris Rosae*, cross-section of an ascoma; 3, *Hypoderma Apocyni*, ascus with spores; 4, *Hypoderma rufilabrum*, cross-section of a hysterothecium; 5, *Clithris leucothoicola*, cross-section of an apothecium; 6, *Clithris Cameliae*, cross-section of an apothecium.

## HISTOLOGICAL STUDIES OF THE BOLETACEAE AND RELATED GENERA<sup>1</sup>

R. P. ELROD & DOROTHY L. BLANCHARD

(WITH 2 FIGURES)

At the present time, a student of the *Boleti* has a choice between a variety of classifications, both as to systematic arrangements of the group with related groups, and as to generic make-up. These fleshy fungi have been made a subfamily of the Polyporeae (5), a family of the Agaricales (8, 10, 13), and a family of a new order, Boletales (4). This family or subfamily has been conceived of as having from one to twelve or thirteen genera. Sartory and Maire (18) would include all *Boleti* and *Phylloporus rhodoxanthus* in a single genus *Boletus*. Peck (15), Patouillard (14), Kallenbach (8) and Bresadola (2) present essentially the same sort of a scheme consisting of three to five genera (Peck leaving out the European *Gyrodon* and Patouillard adding *Tylophilus* to the usual four). This type of arrangement is essentially a modification of that of *Fries* (3), with the genera distinguished on the basis of the more obvious, superficial, macroscopic characters. The other extreme is represented by the plans of Gilbert (4), Singer (20), Konrad and Maublanc (10) and Murrill (13), which are modifications of the plan of Quélet (16) or Karsten (9). Gilbert erects the order Boletales, with two families, Paxillaceae and Boletaceae, with twelve genera in the latter, including *Phylloporus*. He stresses the microscopic characters of the spores. Singer places *Phylloporus* in the Paxillaceae, and divides the *Boleti* into Strobilomycetaceae and Boletaceae, with thirteen genera in the two families. These three families are members of the Agari-

<sup>1</sup> This paper is a summary of the more important data forming the bases of separate theses by the two authors, submitted in partial fulfillment of the requirements for the degree of Master of Science in the Department of Botany in the Graduate School of Brown University, May 1938. The investigations were carried on under the direction of Professor Walter H. Snell.

cales, with the Gomphidiaceae between the Boletaceae and Paxillaceae. Konrad and Maublanc likewise place the Paxillaceae and the Boletaceae in the Agaricales, with *Phylloporus* in the latter, and they modify Gilbert's Boletaceae by making several of the genera into subgenera of the genus *Boletus*. Murrill, in general following Karsten, suggests eleven genera distinguished on the basis of color of the spore print and presence or absence of annulus.

In view of the very plain tendency in Europe to multiply the number of genera in a family that appears to be rather homogeneous, the customary American conservatism in mycology causes one to inquire into the justification of the splitting of the old genera. The most obvious line of study is in the direction of microscopic details. This has been the procedure that has led in part at least to the production of the new systems in the Agaricaceae and apparently to a certain extent in the Boletaceae, although the published material along this line in the latter family is very meagre. Therefore, whether Americans will continue to use Peck's modification of the Friesian scheme of the Boletaceae or ought soon to adopt one of the recent European ones, it is highly desirable that detailed studies be made of the comparatively numerous and more widely diversified representatives of this family on this continent. Partially to accomplish this desideratum and in any event to continue the modest beginning made by Yates (23) a number of years ago, histological studies were made of the pilei of over seventy species of the *Boleti* and related agarics and the species immediately following.

#### FISTULINA HEPATICA

This fleshy fungus with discretely tubular hymenophore has usually been classified as a segregate in the polyporaceous group, without stated relationships to either the polypores or the boletes. Our study of it was undertaken more out of curiosity than with any idea that it was related to the latter group. In the midst of the examination of sectioned material of this fungus there came to hand the article by Lohwag and Follner (11) presenting histological evidence which justified them in placing the genus in the Cyphellaceae.

In general, it may be stated that the structure of *Fistulina* has

nothing in common with that of any of the Boletaceae. The upper portion of the flesh consists of hyphae arranged in a strikingly parallel manner, although lower down they tend to become somewhat interlaced. Above the tubes they are more compacted and they branch and turn down into the hymenophore in such a manner as to make no line of demarcation. The hyphae of the tube walls are strictly parallel, at the edge turning outward into the tube cavity to form the hymenium. There is no evidence of a subhymenium. The basidia are small and distinguishable only with difficulty. No cystidia were found.

In the beginning we had no interest in carrying the study farther, but in view of the conclusions of Lohwag and Follner (loc. cit.), their observations were checked. Our observations as to the origin and growth of the tubules, and the presence of conidia on the upper surface, coincide with theirs. Further, examination of certain Cyphellaceae (*Cytidia salicina*, *Aleurodiscus amorphus*, *A. Oakesii*, *Cyphella villosa*, *C. albo-violacea* and *Solenia anomala*) showed that the structure of these species and of *F. hepatica* is essentially the same, especially in the decidedly parallel arrangement of the flesh hyphae and the nature of the cups.

#### GOMPHIDIUS MACULATUS

In view of the general agreement that the *Gomphidii* are related to the *Paxilli* and the *Boleti*, and especially in view of Lohwag and Peringer's article (12) containing observations on *Gomphidius viscidus* and *G. glutinosus*, *G. maculatus* was studied. In tangential sections, the outermost region of the carpophore consists of tangled hyphae (cutis?) only slightly more compacted than the tissue immediately below it, but the extreme outside of which is definitely gelified, with a thin layer of gluten in places. A subcutis is scarcely distinguishable. The flesh is loose towards the outside, looser and more alveolate below and confluent with the trama of the gills, without any line of demarcation.

The gills of *G. maculatus* are thick and obtuse like those of *G. glutinosus*, not wedge-shaped as in *G. viscidus*, but tapering slightly near the edges only. The gill trama is only slightly and loosely interlaced, with a tendency toward a sub-parallel condition in many

places (FIG. 1, *a*). There is no sign of a differentiated mediostratum and laterostratum. Hence, in this respect *G. maculatus* differs decidedly from *G. glutinosus* with its definitely bilateral trama, and resembles *G. viscidus* with its trama of interlaced hyphae, although the trama of *G. maculatus* is much looser.

The subhymenium is a rather thick, subcompact layer of interlaced hyphae, like that of *G. glutinosus*, but differing from that of *G. viscidus* with its isodiametric cells.

The cystidia are abundant, irregularly cylindric, obtuse, variable, and encrusted.

#### THE GENUS PAXILLUS

The *Paxilli* are more closely related to the Boletaceae than are the *Gomphidii*. A rather complete discussion of the history of the classification of the *Paxilli* has been given by Gilbert (4, pp. 64-69), and his final conclusions are of more than passing interest.

Of the five species of *Paxilli* (with the American *P. corrugatus* the only species not common to both continents), Gilbert makes the following arrangement: *Tapinella panuoides* (Fries) Gilbert, *T. corrugatus* (Atk.) Gilbert and presumably *Paxillopsis atrotomentosus* (Fries ex Batsch) Gilbert in the Agaricaceae; *Paxillus involutus* Fries ex Batsch in the Paxillaceae of the Boletales; and *Phylloporus rhodoxanthus* (Schw.) Bres. in the Boletaceae. Most of the modern workers accept the latter genus as distinct, and many furthermore would place it in the Boletaceae, but they consider the other four species as belonging in *Paxillus* [cf. Konrad and Maublanc (10), Jossierand (7), Romagnesi (17) and Kühner (correspondence with Snell)].

Our studies of the four *Paxilli* may be summarized as follows.

There is no definite cutis in any of the species, although the outer layers of all are slightly compacted. This layer is thick in *P. atrotomentosus* and thin in the other three species.

In all species there are structural features that make for the characteristic ready separability of the gills from the flesh, but there is one difference. In *P. panuoides*, there is a distinct change of direction of the hyphae as they proceed from the flesh into the gills, with a definite line of demarcation between the two, while in the other three species the flesh is in general loose and slightly staining, but quite compact just above the gill layer.

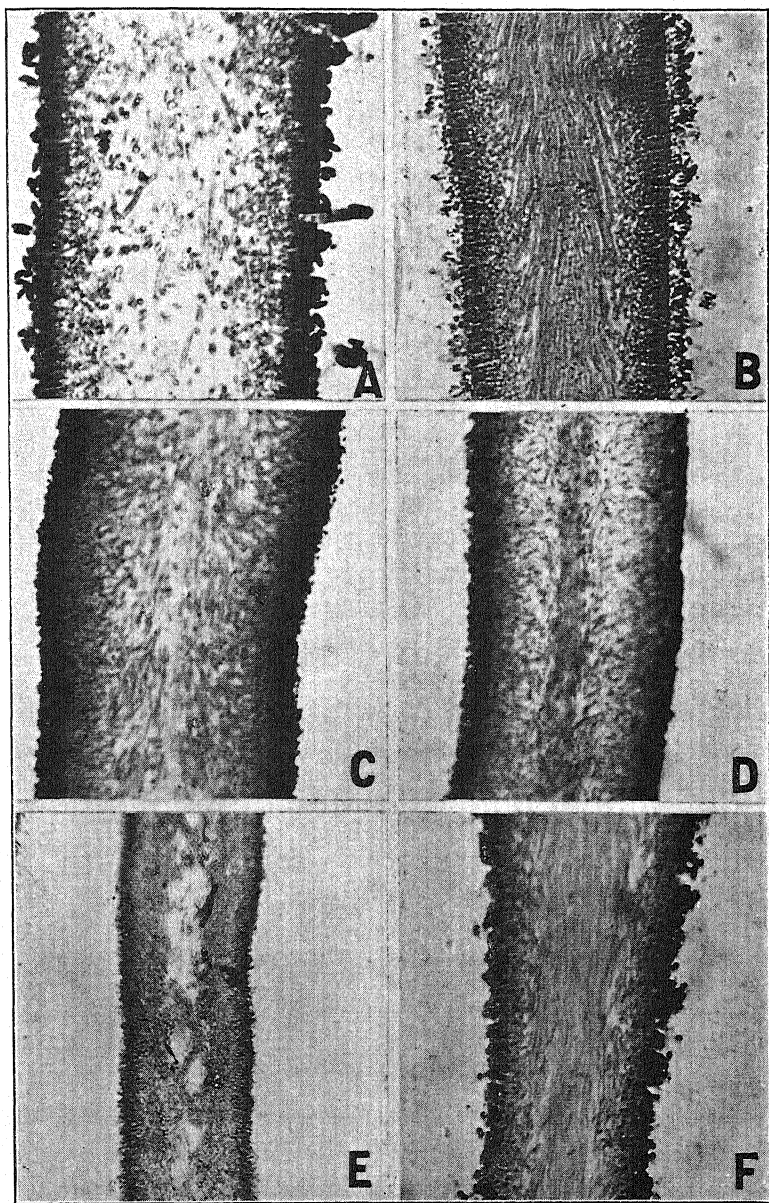


FIG. 1. A, *Gomphidius maculatus*; B, *Phylloporus rhodoxanthus*; C, *Paxillus atrotomentosus*; D, *P. panuoides*; E, *P. corrugatus*; F, *P. involutus*; all  $\times 110$ .



The gill trama is definitely bilateral in *P. atrotomentosus* (FIG. 1, c) and *P. panuoides* (FIG. 1, d) but only indefinitely if at all so in *P. corrugatus* (FIG. 1, e) and *P. involutus* (FIG. 1, f), although Josserand states that it is bilateral in *P. involutus* (7).

The spores of all four species are of the same shape, varying only in size from larger to smaller as follows: *P. involutus*, *P. atrotomentosus*, *P. panuoides* and *P. corrugatus*.

Cystidia are common in *P. involutus*, but absent in the other three species.

Hence, it seems that histological details offer no consistent basis for a segregation of these species in different genera.

#### PHYLLOPORUS RHODOXANTHUS

This species has a well defined, compacted, darkly staining, thin cutis. The flesh is coarser than in any of the *Paxilli*. The hyphae of the flesh change direction more or less gradually into the gill trama, without any distinct line of demarcation between the two. Hence, the gills of this species ought not to be as readily separable as in *Paxillus*. The trama is composed of a very slightly interlaced mediostratum distinguished with difficulty from the laterostratum of parallel hyphae (FIG. 1, b). The cystidia are broadly lanceolate and exceedingly abundant. Hence, this species is structurally different from the *Paxilli* and quite similar to the *Boleti* in sufficient details to support the contentions of those who prefer to place it in the Boletaceae.

#### POLYPOROLETUS SUBLIVIDUS

This species has a plainly visible trichoderm of tomentum 240  $\mu$  thick. The flesh consists of loosely interlaced hyphae down to just above the tubes, where it is compact, with the hyphae running radially and almost parallel. The trama is made up of interlaced hyphae of small diameter and hence is not bilateral. This subhymenium is thin and hardly distinguishable. The basidia are broadly elliptical,  $20 \times 10 \mu$ , with four sterigmata that are long, tubular and wavy, tapering only at the tips. Cystidia were reported by Snell (22), but were not found in our prepared sections.

## STROBILOMYCES STROBILACEUS

This species has a rather distinct cutis, which is covered by thick, tomentose scales. The flesh is very loose and alveolate, appearing spongy. The hyphae of the flesh branch off inconspicuously to form a thin, more or less simple trama of parallel hyphae with no differentiation into mediostratum and laterostratum. The subhymenium is so thin as to be hardly distinguishable. The basidia are clavate-cylindric, short-sterigmate,  $26-40 \times 6-9 \mu$ . Large, ventricose-lanceolate cystidia are abundant and prominent on the tube walls, but scarce at the mouths.

## THE GENUS BOLETINUS

Of the eight species of this genus studied, *B. castanellus* has an unadorned cutis, while *B. spectabilis* and *B. pictus* have a more or less definite cutis adorned with clumps of hyphae which form the characteristic scales. *B. glandulosus* has an ixotrichoderm,<sup>2</sup> and *B. cavipes*, *B. porosus* and *B. squarrosoides* have a trichoderm. In *B. paluster* the covering is more or less flocculose, and in *B. porosus* it may be almost a pile at times.

The flesh of the species examined offers nothing worthy of note, except that in *B. cavipes* there are small, yellow, warted, globular bodies of unknown origin or significance, and that sap hyphae are found in *B. spectabilis*. In none of the species is there any pronounced change of direction of the hyphae from the flesh into the hymenophore and no difference in compactness, etc., between the two portions, except in *B. glandulosus*, in which the hyphae of the hymenophore are somewhat finer and slightly more compact. This general situation is what one would expect, because the tubes of *Boletinus* are separable only with difficulty, if at all.

The tube trama is variable in the species studied. It is bilateral

<sup>2</sup> In the course of these studies Professor Snell coined the term "ixoderm" to describe the gelifying surface layer, and defined it as follows: "a covering of the pileus originally made up of more or less erect, somewhat wavy and more or less interlaced hyphal ends of some length, which later gelify to a greater or lesser degree, to make the surface viscid, viscous or slimy." Lohwag, in correspondence with Professor Snell, suggested that "ixotrichoderm" would be much more precise and Professor Snell accepted the suggestion.

part way down the tubes in *B. glandulosus* (FIG. 2, *a*) and in *B. porosus* (FIG. 2, *b*), and otherwise divergent at the edges; indefinitely bilateral in *B. squarrosoides* and in places in *B. spectabilis*; made up of parallel hyphae in *B. castanellus* (FIG. 2, *c*), *B. paluster* and *B. pictus*, and also for the most part in *B. spectabilis*; and made up of interlaced hyphae in *B. cavipes* (FIG. 2, *d*).

The cystidia are generally cylindrical, clavate or fusiform, with only a few ventricose-rostrate, and single or clustered on the tube walls and at the mouths.

#### BOLETINUS AND BOLETINELLUS

The genus *Boletinellus* was established by Murrill (13), with a characterization but with no discussion or explanation as to the reason for making a new genus. In this latter genus he included *B. merulioides* (*porosus*), although in his keys he separated them as *Boletinus*, annulate, and *Boletinellus*, exannulate.

It so happens that *Boletinus grisellus* and *B. appendiculatus* have no annulus, while *Boletinellus paluster*, with a definite veil when young, often has more that could be called an annulus than either of the foregoing.

Gilbert (4), however, accepts the distinction between the two genera, including *B. porosus* and *B. paluster* in *Boletinellus* [with some misgivings about *B. paluster* (correspondence)], but on the basis of the shortness of the tubes, slightly shorter spores and difference in the color of the spore prints, and not on histological differences. In an article which has appeared since our studies were made, Singer (21) likewise accepts the distinction, but includes *Boletinellus* in *Gyrodon*, with *Phylloporus* between *Boletinus* and *Gyrodon*. He places *B. porosus* (*merulioides*) and *B. castanellus* in *Gyrodon*, *B. rhodoxanthus* and *B. squarrosoides* in *Phylloporus*, and the remaining species in *Boletinus*. These realignments are made at least partially on the basis of microscopic details, but histological features of the species offer no support.

#### THE GENUS BOLETUS

##### *The Covering of the Pileus*

A definite trichoderm is present in: Subpruinosi—*B. pallidus*; Subtomentosi—*B. chrysenteron*, *B. chrysenteroides*, *B. subtomen-*

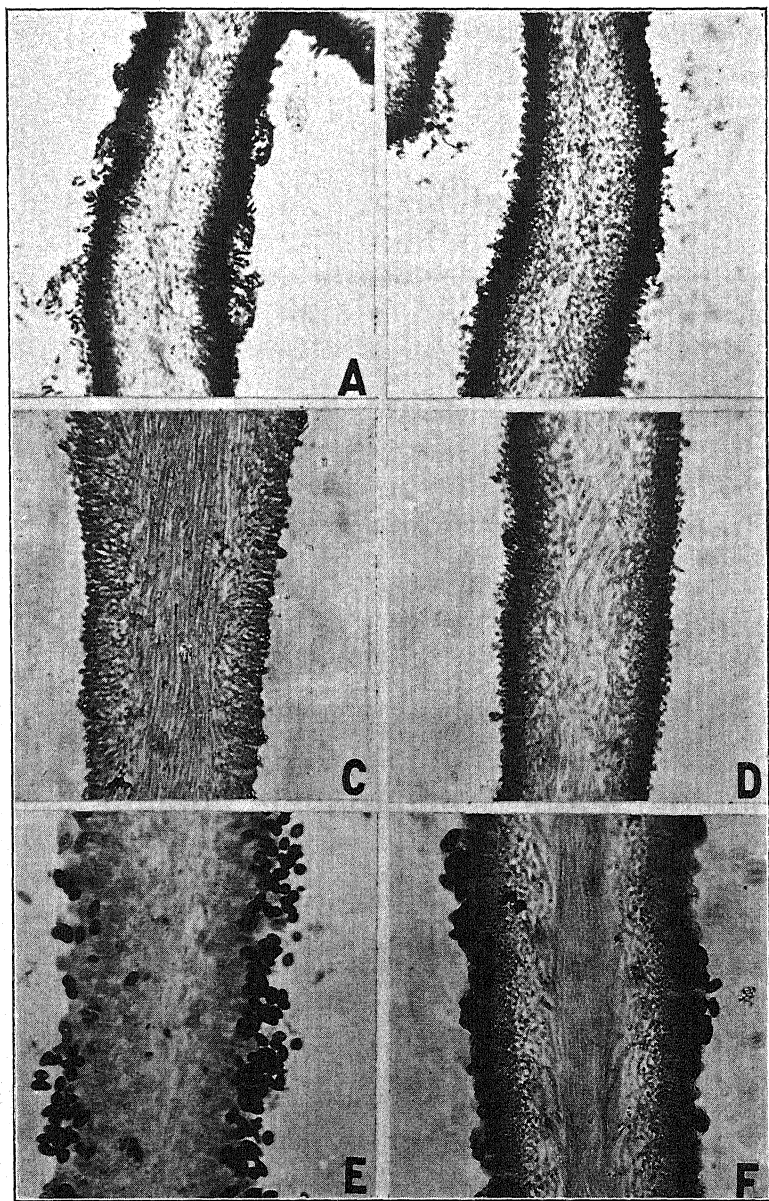


FIG. 2. A, *Boletinus glandulosus*; B, *B. porosus*; C, *B. castanellus*; D, *B. caviipes*; E, *Boletus Russellii*; F, *B. Betula*; all  $\times 110$ .

*tosus*; Laceripedes—*B. Russellii*, apparently the remains of one in *B. Betula*; Calopodes—*B. Peckii*, *B. griseus*, *B. illudens*; Luridi—*B. luridus*, *B. erythropus*, *B. vermiculosus* (in part); Edules—*B. auripes*, *B. variipes*, *B. subdecorus*; Versipelles—*B. leucophaeus*; Hyporhodii—*B. alboater* (in part), *B. felleus*; Cariosi—*B. castaneus*, *B. cyanescens*; Favosi—*B. porphyrosporus*.

It is rather striking that fewer species of *Boletus* than would be expected have a cutis, because so many are glabrous. The situation may be the result of choice of species, inasmuch as only 54 of the 150-odd species of the family were available for study. Furthermore, a cutis was found in the most unexpected species. The list follows: Viscipelles—*B. subaureus*, *B. hirtellus*, *B. piperatus* (instead of an ixotrichoderm, which may have been washed away); Pulverulenti—*B. Ravenelii*; Subpruinosi—*B. roseotinctus*, *B. rugosiceps* (?), *B. alutaceus*; Subtomentosi—*B. subtomentosus* (beneath the trichoderm); Calopodes—*B. modestus*; Luridi—*B. vermiculosus* (more or less), *B. eccentricus*; Versipelles—*B. versipellis*; Hyporhodii—*B. indecisus*, *B. gracilis* (a pseudocutis). There is no true cutis in *B. miniato-olivaceus*—only a compacted outer flesh.

An ixotrichoderm is present in most of the Viscipelles as would be expected, although it is to be noted that three species in the preceding paragraph did not have one in the specimens examined. Such a covering is found likewise in *B. Betula* (Laceripedes) and *B. Frostii* (Luridi).

An epithele is present in *B. scaber*, as was noted by Imler (6), and it affords a good means of distinguishing this species from *B. aurantiacus*, *B. versipellis* and *B. niveus*. This type of covering occurs also in *B. subglabripes* (Subpruinosi) and apparently, strangely enough, in *B. rubeus* of the Subtomentosi.

Bataille (1) erected the genus *Phaeoporus* for *Boletus porphyrosporus* on the basis of the velvety or pilose clothing of the pileus and stipe. Gilbert (4, p. 74) considers this separation as necessary and quotes Kühner (p. 75) as considering the maintenance of this genus as indispensable, because of what they consider an unusual type of pileus clothing in the Boletaceae. Gilbert, however, recognizes that the name *Phaeoporus* is preoccupied as one of the genera of the Polyporaceae created by Schroeter,

and suggests in its place the name *Porphyrellus*. If one is to split up the genus *Boletus* according to any of the many schemes proposed by European mycologists, there is good basis for this genus, but it remains to be seen as to how many other American species will have to be included if the genus is accepted. Such an acceptance may result in difficulties. It would be natural to include *B. fumosipes* with its pilose covering and more or less reddish spores. On the other hand, it is found that *Boletinus porosus* is more or less pilose in certain portions of the mature pileus and that *Boletus variipes* and *B. impositus* of the Edules and *B. alboater* of the Hyporhodii are pilose in varying degrees, the latter especially when young. Also, there are other less well understood species or varieties, such as those which Snell (22) has described as var. *rubrobrunneus* and var. *plumbeoviolaceus* of *B. felleus*, that are velvety to pilose.

#### FLESH

There is nothing of value to be obtained from the flesh characters. In our sections of the pileus this portion varies from species to species within groups and there is no question but that it would vary from specimen to specimen of the same species, depending upon the maturity of the specimen. One thing of interest, however, is the presence of the yellow, globose bodies, warted in most of the species. What they are or what their origin is, cannot be stated. These occur in abundance in *Boletus americanus*, *B. placidus* and *B. piperatus* of the Viscipelles, in *B. roseotinctus* of the Subpruinosi, and in *B. castaneus* and *B. cyanescens* of the Cariosi.

#### SAP HYPHAE

Inasmuch as Lohwag and Follner (loc. cit.) paid considerable attention to the sap hyphae in the Boletaceae which they studied, these structures were noted in the present investigations in order to find out whether or not the presence or absence of them has any significance in the separation of the various groups, subgenera or genera, as the case may be.

In the Viscipelles of the genus *Boletus*, only *B. piperatus* among

the species investigated possesses them. The one species of the Pulverulenti studied, both species of the Laceripedes and two of the three species of the Cariosi do not have them, but in all the other groups there was no uniformity. In the Versipelles, *B. versipellis* has them in abundance, while the other species do not have them; in the remaining groups they occurred in about half the species.

#### BILATERALITY OF THE TRAMA

Although Lohwag and Peringer (loc. cit.) made much of the study of the nature of the trama, there seems to be no need here to be specific concerning this tissue.

Of 46 species of the genus *Boletus* studied, about half possess a trama that is distinctly bilateral or questionably so, while a good half of them show a uniform trama, whether of parallel or of interlaced hyphae. Within the groups (or the proposed new genera), the situation is the same. Of the four species of Versipelles studied, not one has a bilateral trama. In the Hyporhodii, all but one species studied has at least a questionably bilateral trama. In the Cariosi, *B. castaneus* has a definitely bilateral trama, but *B. cyanescens* has one which is definitely not. In the Laceripedes *B. Betula* has a definitely bilateral trama (FIG. 2, f) while that of *B. Russellii* is not bilateral (FIG. 2, e). Hence, unless younger stages provided more definite results, it seems that this character is of no importance in the taxonomy of this group of fungi, as was stated by Sauger (19). Lohwag and Follner (11) did not go so far as to make such a statement but they said that the bilaterality was of irregular occurrence in the Boletaceae.

#### CYSTIDIA

In the Viscipelles, the cystidia are mostly cylindrical-clavate, a few fusiform. We found none ventricose-rostrate, although Snell in his private notes records some in some species. In *B. piperatus*, they are entirely fusiform, a condition different from that in any other species of the group, but this species is aberrant in several respects and apparently represents a connecting link between the Viscipelles and following groups.

In the Subpruinosi, the cystidia are clavate, fusiform or ventricose-rostrate, while in the Subtomentosi they are fusiform to ventricose-rostrate. In the Calopodes, Luridi and Favosi, they are usually ventricose-rostrate, while in the Edules they tend more toward the fusiform.

In the Versipelles, they are rare in *B. scaber*, but abundant in the other three species studied. They are mostly ventricose-rostrate in shape, with some fusiform.

In the Hyporhodii they are rare or lacking in three species but very abundant and unusual in *B. indecisis*. Where present, they are fusiform to ventricose-rostrate.

In the Cariosi, they are rare or lacking on the tube walls, but at the mouths are clavate to subfusiform to ventricose-rostrate.

#### CYSTIDIA IN THE BOLETACEAE

In general, concerning the cystidia in the Boletaceae, the following points may be noted. In *Phylloporus*, they are mostly fusiform or broadly lanceolate, with a few clavate or somewhat ventricose-rostrate. In *Polyporoletus*, none were found by us, but the questionable ones found by Snell were fusiform. The one species of *Strobilomyces* has fusiform cystidia and those in the Edules tend more to the fusiform. *Boletinus* and the Viscipelles of the genus *Boletus* have very similar cystidia (cylindrical-clavate), and this fact only further bears out the generally recognized relationship of the two segregates. In the remaining groups, it may be seen that in the order in which they occur in the Peckian classification, the groups tend progressively to have a greater proportion of the ventricose-rostrate type, with these predominating in the later groups. What this means phylogenetically is a question.

In general, however, it may be said that from the point of view of the taxonomy of the Boletaceae, the cystidia offer no assistance in connection with generic concepts,<sup>3</sup> except possibly the rarity or lack of them on the walls of the Cariosi (genus *Gyroporus*), and that they assist in the determination of species in only a few cases. Sauger (19) stated that they have less value for genera

<sup>3</sup> Cf. Singer (21), however, whose paper appeared after this work was completed.



and species than the spore, that their value is debatable because of their variation in abundance and distribution, and that they are not to be considered as having critical value as a basis for species.

#### GENERAL CONCLUSIONS

From the present histological study of the pilei of nearly half of the American species of the Boletaceae, it would seem that details of structure have little significance either in the older conceptions of the genera with their subgroups, or in the more recent generic segregates, except to a certain extent in *Polyporoletus* and *Strobilomyces* and possibly in part in the pilose genus *Porphyrellus*. In the *Boletinus* and *Boletus* complexes there is no group consistency in the types of covering or clothing of the pileus, flesh characters, sap hyphae or bilaterality of the tube trama. The differences in the cystidia offer assistance only in general or in a few particular instances. Of course, it is necessary to realize that the studies are not complete. Perhaps the study of more of the species will serve to emphasize small differences between genera. Only the pilei have been treated here and even this organ possibly not sufficiently minutely. For example, Singer (21) makes much of differences in the cystidia of the *Boletinus* complex which were not considered in this work.

On the other hand, even on the basis of present progress, histological details are of great value in the elucidation of the problems of species complexes and in the establishment of species concepts. Much clarification of old difficulties has been brought about in recent years through this method of attack.

#### SUMMARY

Histological studies have been made of the pilei of over sixty species of the Boletaceae and a few related species, such as *Gomphidius maculatus*, the *Paxilli* and *Phylloporus rhodoxanthus*. *Fistulina hepatica* was likewise included. The features studied were the clothing of the pileus, the flesh, sap hyphae, nature of the tube trama (especially of the bilaterality or lack of it), and the cystidia.

*Fistulina hepatica* is structurally different from the other species studied, as has been pointed out before.

*Gomphidius maculatus* is contrasted with other species of the genus.

Structural details of the *Paxilli* offer no basis for segregation of the species in different genera or in different families.

*Phylloporus rhodoxanthus* is structurally different from the *Paxilli* and sufficiently similar to the *Boleti* to justify placing it in the Boletaceae, if on other grounds this disposition of it appears desirable.

In *Boletinus* and in *Boletus* and its subgroups in the Peckian scheme, on the basis of information available at present, histological details appear to be of little significance for the making of generic or group distinctions. They are, however, of value in solving problems of species and in the establishment of species concepts.

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#### EXPLANATION OF FIGURES

FIG. 1. Cross sections of lamellae. *a*, *Gomphidius maculatus*, with undifferentiated, interlaced trama. *b*, *Phylloporus rhodoxanthus*, with divergent type of trama hardly differentiated in the mediostratum and laterostratum. *c*, *Paxillus atrotomentosus*, with indistinctly bilateral trama. *d*, *P. panuoides*, with definitely bilateral trama, showing distinct mediostratum and laterostratum. *e*, *P. corrugatus*, with trama hardly bilateral if at all so. *f*, *P. involutus*, with parallel trama. All  $\times 110$ .

FIG. 2. Longitudinal sections of tube walls. *a*, *Boletinus glandulosus*, and *b*, *Boletinus porosus*, with trama bilateral part way down, and divergent below. *c*, *Boletinus castaneellus*, with trama of parallel hyphae. *d*, *Boletinus cavipes* with trama of interlaced hyphae. *e*, *Boletus Russellii*, with trama of interlaced hyphae. *f*, *Boletus Betula*, with definitely bilateral trama. All  $\times 110$ .

## STUDIES ON ASCOSPORE VARIANTS OF HYPOMYCES IPOMOEAE

A. W. DIMOCK \*

(WITH 6 FIGURES)

The writer has alluded in earlier papers (1, 2) to certain variant strains which originated as the primary growth from single ascospores isolated from *normal*  $\times$  *normal* and *normal*  $\times$  *aborta* perithecia of *Hypomyces Ipomoeae* (Hals.) Wr. These strains were designated as "ascospore variants" (3) to distinguish them from the "natural variants" and "induced variants" which had their origin in the gametophytic mycelium of the *normal* strain. While studies on these ascospore variants were somewhat limited, the results were so striking and suggestive that a more detailed review is here presented.

### THE PURPLE VARIANT

First to be considered is the *purple* variant which appeared in the progeny of both *normal*  $\times$  *normal* and *normal*  $\times$  *aborta* perithecia (1, 2). The variant differs from *normal* in the development of purple pigment in hyphae and culture medium, in the production of fewer microconidia, in the lack of tan macroconidium masses at the colony centers, and in weaker sex-reaction (FIG. 1a). The strain develops no perithecial fundaments, and although producing perithecia readily when mated with *normal*, produces very few when inbred. A total of 46 pure *purple* cultures appeared in a population of 485 single-ascospore cultures obtained from 6 *normal* inbred and 6 *normal*  $\times$  *aborta* perithecia. In addition, sectors of *purple* growth appeared in two of the cultures of the *normal* type obtained from perithecium El, one originating at the inoculum, the other apparently originating at a point 15 m.m. distant from the inoculum. The distribution of *purple*

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variants and sex-reaction groups in the single-ascospore populations are indicated in Table 1. The two *normal* cultures which

TABLE 1  
DISTRIBUTION OF *purple* VARIANTS AND SEX-REACTION GROUPS  
IN THE PROGENY OF *normal*  $\times$  *normal* (E) AND  
*normal*  $\times$  *aborta* (T) PERITHECIA

Perithecium	<i>purple</i>		<i>normal</i> <sup>a</sup>		Per cent <i>purple</i>
	<i>a</i>	<i>A</i>	<i>a</i>	<i>A</i>	
E1	3	1	5	11	20 <sup>b</sup>
E2	1	1	15	11	7
E3	1	0	25	11	3
E4	4	5	4	7	45
E6	0	0	23	28	0
E7	0	0	8	10	0
T3	1	1	24	36	3
T4	0	0	5	3	0
T5	8	0	25	19	15
T6	7	10	58	43	16 <sup>c</sup>
T7	1	2	22	18	7
T8	0	0	10	16	0
Total	26	20	224	213	10

<sup>a</sup> Includes both *normal* types and ascospore variants other than *purple*.

<sup>b</sup> Includes 2 "mixed" cultures.

<sup>c</sup> Includes 2 *purple* variants of undetermined sex-reaction group.

possessed *purple* sectors, both of which bore sex-reaction factor *a*, are considered as *purple*. The sex-reactions of two of the *purple* cultures obtained from perithecium T6 were not determined.

It is seen that with the exception of perithecium E4, the percentage of *purple* variants in the progeny of any single perithecium is too low to be explained by the assumption of a unifactorial difference for the *purple* character in the parent cultures. Furthermore, the *purple* character has never appeared in any of the hundreds of mass-transfer or single-microconidium cultures of the parent strains which have been studied in this work. Perithecium E4 is believed to have been a secondary perithecium which developed as the result of spermatization of a *normal* perithecial fundament by a *purple* ascospore expelled from a primary perithecium in the same culture tube. Both E3 and E4 were taken at the same time from a culture tube mating of the *normal* tester strains (3-3, *A* and 3-14, *a*). E3 was an old perithecium exuding

ascospores, whereas E4 was an adjacent perithecium which contained a relatively small number of mature asci and whose ostiole had not yet opened.

Single-ascospore isolations were made from three *normal*  $\times$  *purple* back-cross perithecia. The developing mycelia were classified as to phenotype, and the sex-reaction groups of the *normal* cultures were determined. The results are given in Table 2.

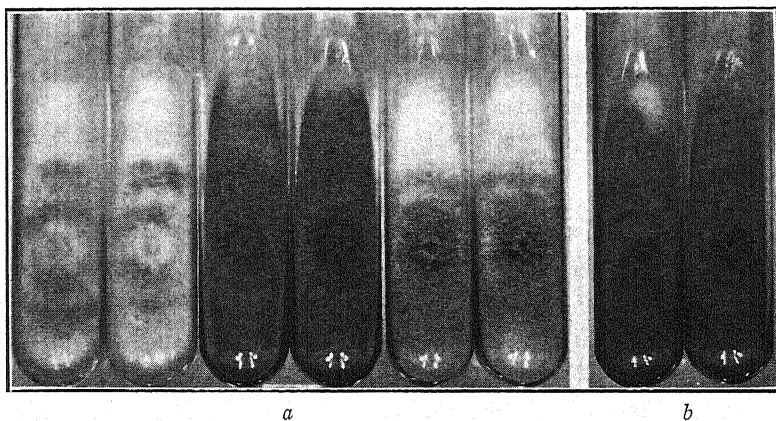


FIG. 1. *a*, Two single-conidium cultures each of *normal*, *purple*, and a "reverted" strain obtained from a *purple* culture. *b*, Sector of "reverted" mycelium in the *purple* growth at the top of a single-conidium culture of the *purple* strain.

TABLE 2  
*Normal*  $\times$  *purple* BACK-CROSSES

Perithecium	<i>purple</i>	<i>normal</i>		Per cent <i>purple</i>
		<i>a</i>	<i>A</i>	
P1 ( <i>normal</i> , <i>A</i> $\times$ <i>purple</i> , <i>a</i> ) ..	18	7	4	62
P2 ( <i>normal</i> , <i>a</i> $\times$ <i>purple</i> , <i>A</i> ) ..	10	7	29	22
P3 ( <i>normal</i> , <i>A</i> $\times$ <i>purple</i> , <i>a</i> ) ..	13	6	4	57
Total.....	41	20	37	42

While populations are too small to permit extensive conclusions, it appears that the phenotypic expression of the variant is controlled by genetic factors. Furthermore, it is indicated that a single allelomorph pair which segregates independent of the sex-

reaction factors is involved, though more detailed work would be required to check this point.

Single-ascospore isolations were made from a single *purple*  $\times$  *purple* perithecium, and of the resulting cultures 25 were *purple* and 15 were *normal*. Seven of the *normal* cultures bore the sex-reaction factor *A*, eight the factor *a*. The sex-reaction groups of the *purple* cultures were not determined. The large number of *normal* cultures in this population of 40 indicates either that the *purple* factor or factors had reverted to *normal* in one of the parent mycelia prior to perithecium formation, or that there had been a high percentage of reversion to *normal* during the maturation divisions in the asci. The former assumption is favored by the facts that perithecial fundaments were never observed in pure *purple* cultures and that sectors of "reverted" growth did appear in occasional *purple* cultures (FIG. 1b). Mass transfers from one such sector yielded cultures appearing very much like *normal*, though single-spore cultures made from one of the latter showed that while the change had been "in the direction" of *normal*, the reversion was not quite complete (FIG. 1a). The suggestion that the reversion occurred during the maturation divisions in the asci is favored by the fact that the original mutations from *normal* to *purple* undoubtedly occurred during meiosis.

Somewhat similar variants in *Neurospora* have been reported by Lindegren (6, 7) and by Wülker (8). The former found a tan variant of *N. crassa* to be conditioned by factors which exhibited considerable instability. The latter has shown a similar condition to exist with factors (*L/1*) for presence or lack of aerial mycelium in a strain of *N. sitophila*. Both workers showed by single ascus analysis that reversion may occur as the result of monogenic conversion during the maturation divisions in the ascus. Wülker also noted mutation of the factor *1* to *L* in vegetative mycelium. Unfortunately, single ascus analysis has not been possible in the present work, so that information concerning the frequency of conversion of the *purple* factor (or factor-group) in the maturation divisions is lacking. The writer is inclined to the opinion that the factors involved are quite labile and that, as in *Neurospora*, conversion is favored during the maturation divisions.

## THE VINIFERA AND ALBA VARIANTS

Among the single-ascospore progeny of the *normal*  $\times$  *normal* perithecium E3, appeared one culture which showed striking differences from *normal*. The initial growth-rate was so much slower than *normal* that the spore was nearly discarded as dead. The growth-rate soon increased, however, and after a few days the culture possessed a leathery basal structure, became strongly fluted at the center, and developed a marked greyish-purple pig-

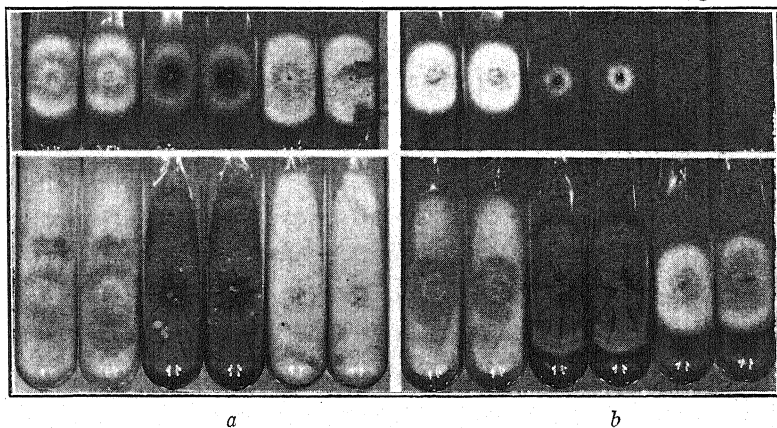


FIG. 2. *a*, Two single-conidium cultures each of *normal*, *vinifera*, and *alba*. Upper, 4 days old; lower, 9 days old. *b*,  $f_1$  gametophytes from a *normal*  $\times$  *vinifera* perithecium. Left to right: 2 *normal*, 2 *vinifera*, and 2 slow-germinating mycelia which later developed apparently *normal* growth. Upper, 2 days old; lower, 7 days old.

ment both in the mycelium and in the medium (FIG. 2*a*). The mycelium produced very few conidia, and those only after the lapse of a week or more. Perithecium formation, which occurred in back-crosses with the *normal* tester-strain 3-3(*A*), was considerably slower than in matings of the two *normal* strains. The variant will be called *vinifera*.

Nineteen single ascospores were isolated from a *normal* (*A*)  $\times$  *vinifera* (*a*) perithecium. Eight of these developed *vinifera* cultures, and nine developed *normal* cultures, while two produced almost no growth until three days had elapsed, but eventually developed apparently *normal* cultures (FIG. 2*b*). Of the eleven



*normal* cultures, three possessed the sex-reaction factor *A*, eight the factor *a*. Of the *vinifera* cultures, two were found to bear the factor *A*, and two the factor *a*. The sex-reactions of the remaining four *vinifera* cultures were not determined.

No sign of reversion appeared in the original single-ascospore culture or in mass-transfer sub-cultures of the *vinifera* strain. Fifteen single-microconidium cultures were made from the original culture, however, and of these only four developed *vinifera* mycelia, while the other eleven developed an entirely new type. The new type, *alba*, was almost devoid of pigmentation, the mycelium forming a snowy mass (FIG. 2a). Growth-rate was about as in the *normal* strains, but conidium production was as limited as in the *vinifera* strain. The new strain proved quite constant in mass-transfer and single-conidium cultures. The nature of the change suggests that again a reversion "in the direction" of the *normal* had occurred.

Thirty-two single-ascospores were isolated from a *normal* (*A*)  $\times$  *alba* (*a*) perithecium. Fourteen developed *normal* cultures, ten developed *alba* cultures, seven developed *vinifera* cultures, and one developed another variant type, *restricta*, which will be discussed later. The distribution of sex-reaction factors was found to be as follows:

	<i>normal</i>	<i>alba</i>	<i>vinifera</i>	<i>restricta</i>
<i>A</i> :	5	2	3	1
<i>a</i> :	9	8	4	0

The populations, though small, serve to indicate that *vinifera* differs from *normal* in a single factor or closely linked factor-group. *Alba* may have arisen from *vinifera* either by further mutation of the *vinifera* gene (the suggested reversion "in the direction" of *normal*) or by mutation of an independent gene. The second possibility is perhaps best in keeping with the observed fact that *vinifera* may reappear in the progeny of *normal*  $\times$  *alba* matings. Thus, if the *alba* phenotype were governed by an *alba* gene operative only when present with the non-linked or only loosely linked *vinifera* gene, the appearance of *normal*, *vinifera*, and *alba* in an approximate 2:1:1 ratio would be expected in the progeny of an *alba*  $\times$  *normal* mating. The *restricta* culture is not believed

to be an expression of any arrangement of *vinifera* or *alba* genes. It is evident that the *vinifera* and *alba* genes are not linked to the sex-reaction genes.

#### THE ALBIDA VARIANT

This variant originated from a single ascospore in a population of sixty-two obtained from a *normal*  $\times$  *aborta* perithecium. The appearance of the culture did not differ strikingly from the *normal*, and closely resembled the *alba* type in its abundance of snow-white

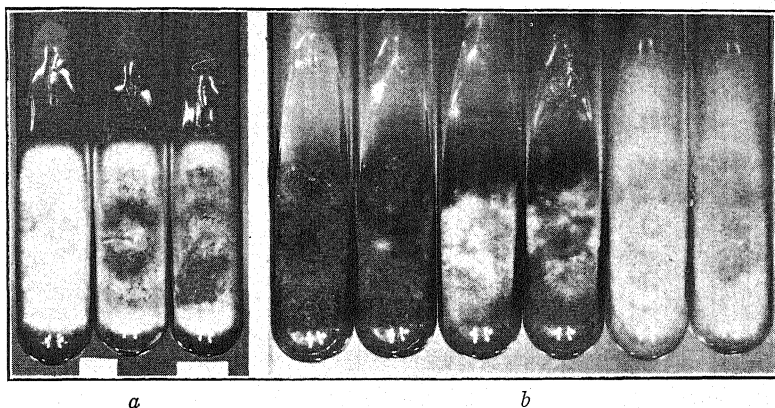


FIG. 3. *a*, Left to right: typical *albida* variant, "reverted" mycelium obtained from a pure *albida* culture, and *normal* tester-strain. *b*,  $f_1$  gametophytes from a *normal*  $\times$  *albida* perithecium; 4 gametophytes of the striking aberrant type on the left, and 2 *normal* gametophytes on the right. Note the "reverted" mycelium developing irregularly in the aberrant tubes.

mycelium (FIG. 3*a*). Ten single-microconidium cultures of the *albida* strain were obtained from the original culture two weeks after its isolation, and ten more were obtained from the same culture four weeks later. Of the first series, nine were of the *albida* type and one *normal*, while of the second series, nine were *normal* and only one *albida*. The *normal* cultures were almost indistinguishable from a comparable series of *normal* tester-strain cultures (FIG. 3*a*). Thus another ascospore variant showed almost complete reversion to *normal*.

Twenty-two single-ascospore cultures were obtained from a *normal* (*A*)  $\times$  *albida* (*a*) perithecium. This progeny yielded most

unusual results. Twelve of the ascospores gave rise to *normal* cultures, one gave rise to a culture of the *restricta* type, and the remaining nine developed cultures of an entirely new type whose initial growth, though of almost *normal* growth-rate, was so sparse as to be detectable only when the slopes were properly inclined to the light. Eventually, however, the growth of these aberrant cultures became denser and produced a brick-red pigmentation of the hyphae and considerable pigmentation of the medium. Soon patches or aerial sectors, and marginal sectors, apparently of *normal* growth, appeared on all these colonies (FIG. 3*b*). Although detailed studies of these cultures were not carried out, it was observed that in transfers made from the tubes to fresh agar slopes for sex-reaction tests, some gave rise to apparently *normal* cultures and others yielded cultures resembling their own original growth. It should be noted that not one of the twenty-two single-ascospore cultures bore any resemblance to the *albida* parent.

Tests for sex-reaction groups showed that eleven of the *normal* cultures possessed the factor *a*, and only one the factor *A*. Of the new-type cultures, three bore the factor *a*, and four the factor *A*. The sex-reactions of the remaining two new-type cultures and of the *restricta* culture were not determined.

While these results have yielded little information concerning the nature of the *albida* variant, it is evident that it is exceedingly labile, and that its intrinsic differences from *normal* effect profound disturbances in the hereditary mechanism within hybrid (*normal*  $\times$  *albida*) asci.

#### THE CONVOLUTA VARIANT

The *convoluta* variant originated as one of eight single-ascospore cultures from a *normal*  $\times$  *aborta* perithecium. Growth of *convoluta* mycelium was very slow, but not sparse. The basal mycelium formed a leathery layer, and the center of the colony became markedly raised and convoluted. After the colony had attained a diameter of three to four centimeters (on potato-dextrose agar), growth apparently ceased, but eventually marginal growth was resumed, either quite regularly, or as sectors, and the entire surface of the slope became covered (FIG. 4*a*). The mycelium early took on a strong purplish hue, and considerable purple pig-

ment was diffused into the medium. Conidium production was very weak, as in the *vinifera* variant previously discussed.

Nine single-conidium cultures obtained from the original single-ascospore mycelium developed true to the *convoluta* type. Following the primary growth period one of the cultures developed particularly well marked sectors of secondary growth. One of these was fluffy and white, and bore numerous conidia, strongly resembling the *normal* type. The other was composed of very sparse, resupinate hyphae. Two mass-transfers were made from each sector, from the central growth of the same culture, and from

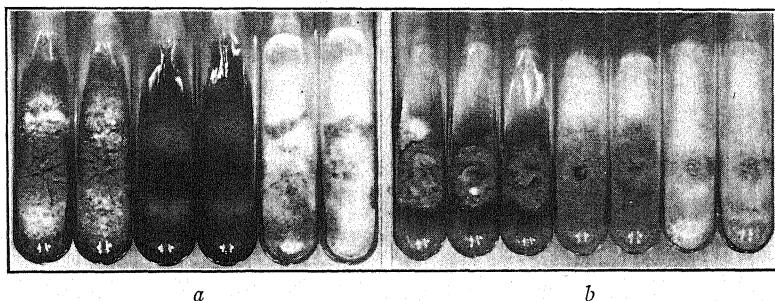


FIG. 4. *a*, 13-day-old cultures obtained from one single-conidium culture of the *convoluta* strain. Left to right: 2 transfers from central *convoluta* mycelium, 2 transfers from a sector which developed at the top of the primary *convoluta* mycelium, and 2 transfers from a "reverted" sector at the bottom of the primary *convoluta* growth (see text). *b*, Left to right: 3 *convoluta* gametophytes, 2 gametophytes of the intermediate type (see text), and 2 *normal* gametophytes from a *normal*  $\times$  *convoluta* perithecium.

the central growth of another *convoluta* culture which had not started secondary growth. The two transfers from the *normal*-type sector yielded apparently *normal* cultures, the four transfers from *convoluta* growth yielded *convoluta* cultures, and the two transfers from the sparse sector yielded an entirely new type of growth (FIG. 4a).

The new type of growth was resupinate, produced strong reddish pigmentation of the hyphae and medium, and developed no convolutions at the centers of the cultures. The initial growth-rate of these cultures was intermediate between that of the *convoluta* and *normal* types, but due to rapid staling they were soon surpassed

by the secondary growth of the *convoluta* cultures (FIG. 4a). No further study of this strain was made.

Twenty-four single-ascospores were isolated from a *normal* (*a*)  $\times$  *convoluta* (*A*) perithecium. Twelve of these developed *normal* cultures, six developed *convoluta* cultures, and six developed cultures differing from the *normal* type in the possession of a slightly slower growth-rate, in the development of a grey-green cast, and in the lack of the tan macrospore masses over the inoculum which form so conspicuous a feature of all *normal* cultures (FIG. 4b). The high percentage of cultures of this type and their uniformity suggest Mendelian recombination. Sex-reaction factor determinations showed the following distributions:

	<i>normal</i>	<i>convoluta</i>	new type
<i>A</i> :	8	5	4
<i>a</i> :	4	1	2

The population is again too small to permit extensive conclusions, but suggests that *convoluta* differs from *normal* by one or more Mendelian factors. No linkage with the sex-reaction genes is evident. Recovery of apparently *normal* cultures from vegetative mycelium of the *convoluta* strain indicates that the gene or genes involved are unstable and capable of reverting to the *normal* state.

#### THE REVERTA VARIANT

The *reverta* variant developed from a single ascospore in a population of one-hundred and twenty isolated from a *normal*  $\times$  *aborta* perithecium. The remainder of the spores developed either *normal* cultures or cultures of the *purple* variant previously discussed. The *reverta* type differed from *normal* in an extremely slow growth-rate, a deep red pigmentation of mycelium and medium, a fluting of the colony center, an almost total lack of normal conidia, and a resupinate habit (FIG. 5). Microscopic examination of the hyphae showed them to be composed of short, stout cells which readily became disengaged from one another, thus resembling abnormal conidia. Whether or not true conidia were formed was uncertain; if so, they were very rare and quite abnormal.

It was noted that when the original *reverta* culture was removed

from the 27° C. incubator after five days,<sup>1</sup> growth of *reverta*-type mycelium apparently ceased. The day after removal from the incubator, sectors of apparently *normal* hyphae started from the margin of the *reverta* mycelium (FIG. 5a). No further extension

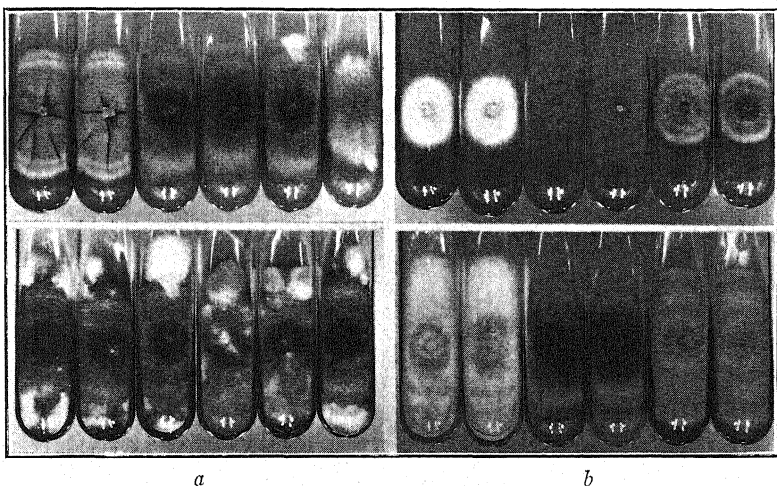


FIG. 5. *a*, Upper, 2 *vinifera* cultures on the left, and 4 *f<sub>1</sub> reverta* gametophytes from a *normal* × *reverta* perithecium on the right. Lower, sectors of "reverted" mycelium appearing in typical *reverta* cultures 6 days after removal from 27° C. chamber. *b*, Left to right: 2 *normal*, 2 *reverta*, and 2 *restricta* gametophytes from a *normal* × *reverta* perithecium. Upper, 3 days old; lower, 7 days old.

of the *reverta* mycelium occurred, but the top and bottom of the slope became covered with *normal* growth. Before extensive development of the reverted sectors had occurred, twelve single-cell (or conidium) cultures were obtained from the *reverta* mycelium. Ten of these were treated exactly as the original *reverta* culture had been treated, and behaved in exactly the same manner, though the growth-rate of the *reverta*-type mycelium varied from tube to tube. The other two cultures were placed in a 23° C. rather than a 27° C. chamber and at the end of two days showed no growth whatever. They were then placed in the 27° C. chamber and growth of *reverta*-type mycelium commenced at once. When re-

<sup>1</sup> Throughout this study all cultures were placed in a 27° C. chamber for the first five or six days of growth and then removed to the laboratory table.

moved to the laboratory table three days later, growth of *reverta* mycelium immediately ceased. One tube was subsequently replaced in the 27° C. chamber and growth of *reverta* mycelium was resumed. Sectors of *normal* mycelium eventually appeared in both tubes.

In another test, five single-cell cultures obtained from a young *reverta* colony were removed from the 27° C. chamber after five days and placed on the laboratory table, while five others were allowed to remain in the incubator. Those removed from the incubator ceased development of *reverta* mycelium and immediately formed *normal*-type sectors, whereas those left in the incubator continued to develop *reverta*-type mycelium until the slopes were covered, weak sectors appearing in only two of the five tubes. In all cases transfers from sectors yielded pure *normal*-type colonies, whereas transfers from *reverta* mycelium in young cultures yielded *reverta* cultures. Eventually, however, reversion became complete throughout the colonies, for numerous attempts to recover the *reverta* type by single-cell or mass transfers from cultures two weeks old were wholly unsuccessful, all transfers yielding pure *normal* cultures.

Back-crosses to the *normal* tester-strains had been made from the original *reverta* culture before extensive development of the reverted sectors. The *normal* mycelium in the matings quickly overgrew the slower *reverta* mycelium, but eventually perithecia were formed in the *normal*  $A \times reverta$  cross, showing that the *reverta* mycelium possessed sex-reaction factor *a*. Although it was considered probable that the perithecia were formed only after the *reverta* mycelium had reverted to the *normal* type, thirty single-ascospore cultures were made from one of the hybrid perithecia. Of these, fifteen developed cultures of the *reverta* type, thirteen developed cultures of the *normal* type, and two developed cultures of the *restricta* type (FIG. 5*b*). The distribution of sex-reaction factors was found to be as follows:

	<i>normal</i>	<i>reverta</i>	<i>restricta</i>
<i>A</i> :	4	6	0
<i>a</i> :	9	9	2

The data indicate that the *reverta* phenotype is determined by

one or more Mendelian factors which are sufficiently stable to segregate somewhat normally in the maturation divisions. It is possible that some reversion occurred during meiosis, though this could be proved only by tetrad analysis. All the *reverta* cultures in the back-cross progeny developed sectors of reverted mycelium exactly as had the parent *reverta* isolate and its sub-cultures. Perpetuation of the *reverta* strain would therefore be extremely difficult at room temperature, though the experiments suggest the possibility of perpetuation of the strain by cultivation exclusively at high temperatures. The *reverta* gene or genes are apparently not linked with the sex-reaction genes.

#### THE RESTRICTA VARIANT

The *restricta* variant, while less striking than some of those previously discussed, is of considerable interest because of its appearance in four different populations. It first appeared as one single-ascospore culture in a population of twenty-six obtained from a *normal*  $\times$  *aborta* hybrid perithecium. The variant again appeared in the progeny of *normal*  $\times$  *alba*, *normal*  $\times$  *albida*, and *normal*  $\times$  *reverta* back-crosses, one ascospore in each of the first two, and two in the third, yielding cultures indistinguishable from the original *restricta* type. This variant differed from *normal* in the production of silky hyphae which developed an even, reddish pigmentation. The medium soon became somewhat fluted at the center and showed marked restriction of development at the top of the slopes, the agar surface never becoming completely covered (FIGS. 5b, 6).

The *restricta* variant was more stable than the other variants in mass-transfer and single-conidium cultures. A white, fluffy sector resembling *normal* appeared in one single-conidium culture, however. Transfers from this sector yielded cultures which varied from the *restricta* type "in the direction" of the *normal*, whereas transfers from *restricta* growth in the same tube yielded typical *restricta* cultures (FIG. 6).

The first observed *restricta* variant was mated with both *normal* tester-strains and found to bear sex-reaction factor *A*. Of twenty-one ascospores isolated from one of the resulting perithecia,



nine developed *normal* and twelve developed *restricta* cultures. Six *normal* and seven *restricta* cultures were found to bear sex-reaction factor *A*, three *normal* and three *restricta* the factor *a*. The sex-reactions of the remaining two *restricta* cultures were not determined.

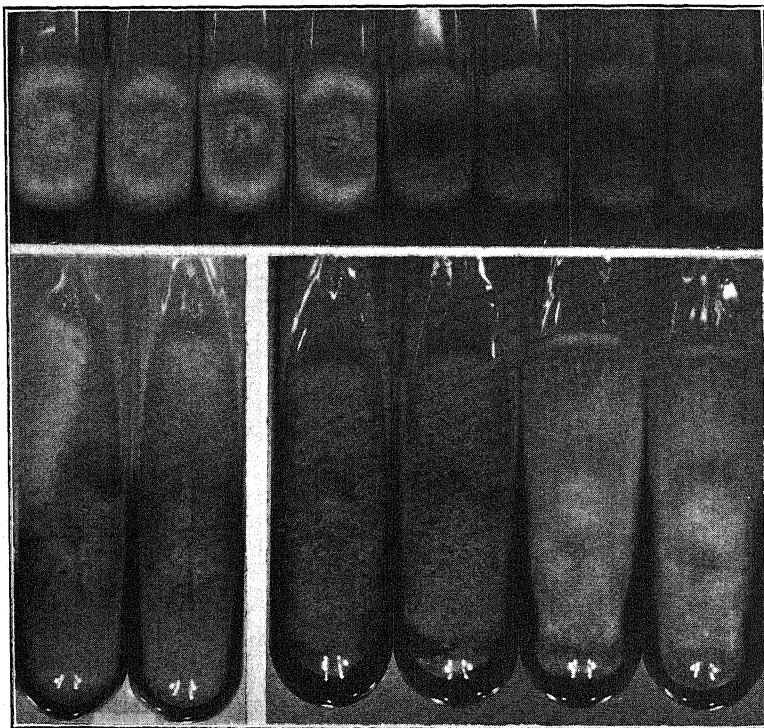


FIG. 6. Upper, 4 four-day-old cultures each of *normal* and *restricta* strains; the 4 central cultures are  $f_1$  gametophytes from a *normal*  $\times$  *restricta* perithecium. Lower left, sector of "reverted" growth appearing in one of two single-conidium cultures of *restricta*. Lower right, two mass transfers each from the *restricta* growth and from the "reverted" sector in the sectoring culture illustrated.

These data indicate that *restricta* characters are conditioned by one or more Mendelian factors. There appears to be no linkage between the *restricta* factors and the sex-reaction factors. The factor or factors, while relatively stable, are capable of variation toward *normal* in monoploid vegetative cells. The appearance of

this variant in four distinct hybrid perithecia suggests that mutation of the gene from *normal* to *restricta* may occur with some frequency during maturation divisions in hybrid asci.

#### DISCUSSION ON ASCOSPORE VARIANTS

Several variants of the type considered in this paper have been recorded in the literature. The "albinistic" strain of *Neurospora sitophila* noted by Dodge (4, 5) first appeared as a single-ascospore culture obtained from a perithecium resulting from a mating of his strains Arl. 6 and Arl. 10. Consideration of his papers leads to the opinion that the strain Arl. 10 was heterocaryotic, bearing both "conidial" and "albinistic" nuclei. Both Dodge and Wülker (8) have shown that this factor pair segregates at meiosis independent of the factors for sex-reaction.

Lindegren (6) studied six variants from the *normal* type in *Neurospora crassa*. The *tan* mutant appeared as a single-ascospore variant in the third inbred generation of the *normal* type. The other five mutants all appeared as ascospore variants in the lineage of a single *normal*  $\times$  *tan* hybrid ascus. It is noteworthy that the asci yielding the variants were all obtained from perithecia resulting from *normal*  $\times$  *normal* rather than *normal*  $\times$  *tan* or *normal*  $\times$  "variant" crosses. Lindegren attributes only the appearance of the *tan* strain to gene mutation, the remainder presumably resulting from the segregation of preëxisting genes. The *tan* mutant is of considerable interest since Lindegren (6, 7) has shown that the *tan* gene reverts to *normal* with high frequency, both in the vegetative cells and during the maturation divisions. Mutation from *normal* to *tan* was also found to be a recurrent phenomenon, though taking place much less frequently than the back-mutation from *tan* to *normal*. The behavior of this mutant strongly resembles that of the *purple* variant discussed in the present paper.

Zickler (9) has made a thorough study of ascospore variants appearing in the progeny of hybrid asci of *Bombardia lunata*. Four such variants came to his attention during analyses of all eight spores in individual asci. Each appeared as the primary growth of two adjacent spores which should have yielded mycelia of one of the parent types. The mutations obviously occurred in one chromatid of the tetrad. The hereditary character of some

of these variants was proved by hybridization studies. Zickler further noted the back-mutation in the heterozygote of a mutant which had first appeared as a sector variant in vegetative mycelium, and whose hereditary nature had been proved. Usually the mutation or back-mutation occurred in but one chromatid of the tetrad, though in two cases mutation of the same gene occurred in both sister chromatids.

Wulker's work (8) on the factors for the presence or absence of aerial mycelium in a strain of *Neurospora sitophila* has already been mentioned. Mutation of these genes both in the maturation divisions and in vegetative mycelium occurred with considerable frequency, as was the case with Lindegren's *normal-tan* and the writer's *normal-purple* factor pairs. Wülker, like Zickler (9), observed that in maturation divisions mutation in a single chromatid was more frequent than mutation in both sister chromatids, and also that mutation in a single chromatid was more frequent than failure of mutation in both chromatids. To explain this frequent mutation, he proposed three hypotheses: (1) that the cause lies purely in the labile nature of the genes; (2) that the conversion is favored by the simultaneous presence of both members of the allelomorphic pair in the heterozygote; and (3) that the high mutation rate is attributable to the presence of an independent, non-linked "Umschlagfaktor" pair, the presence of the dominant allele *U* in a gamete either suppressing expression of one of the mycelial character factors or favoring or inducing its mutation. Wülker further noted the appearance of an ascospore variant which inhibited ascospore maturation, and of another which caused a striking restriction of mycelial growth.

The experiments outlined in this paper, limited as they were, have strongly indicated that the variants discussed, with the possible exception of *albida*, were the result of true gene mutation. The fact that four of the strains (*purple*, *albida*, *convoluta*, and *reverta*) showed apparently complete reversion to *normal* in the monoploid vegetative cells suggests that the mutations have been of the nature of inactivation or alteration of the *normal* or wild-type genes. Had the wild-type genes suffered deletion, reversion to *normal* would be difficult to conceive, particularly in gametophytic cells.

It is significant that although more than one thousand single-conidium and mass-transfer cultures of the *normal* strain have been carefully observed during the work on *Hypomyces Ipomoeae*, only one spontaneous sector variant sufficiently different from *normal* to be detected arose (3). Furthermore, neither this variant nor an induced variant (2), which also arose in gametophytic cells, has shown any tendency to reversion or further mutation, though more than one hundred and fifty single-conidium and mass-transfer cultures of each have been closely studied. In contrast to this, six distinct and striking variants have appeared as the primary growth of individual isolated ascospores although the number of single-ascospore cultures studied has been less than half the number of single-conidium cultures. Note further that, excluding *purple*, four of the five remaining ascospore variants have appeared only in the progeny of hybrid perithecia, and that all have shown a tendency to reversion, further mutation, or both.

The inference is inescapable that mutation is favored during the stress of the meiotic nuclear divisions. Zickler (9) and Wülker (8) were likewise, as a result of their studies, forced to this conclusion. The observations of these workers and of the writer suggest, moreover, that mutation is particularly favored in the maturation of heterozygotes. The present studies indicate further that the effect may be carried over into subsequent gametophytic cells, possibly as the result of mitotic abnormalities or unusual stress, leading to reversion or further mutation of the affected gene or genes.

The subject can scarcely be left without a brief consideration of the biological significance of ascospore variants. The following facts concerning these variants have been observed during the course of the work: (1) all have possessed growth-rates slightly or markedly slower than *normal*; (2) all have been poorer in the production of conidia, some being almost non-conidial; (3) with the possible exception of the *alba* variant, all have shown low fertility in back-crosses to *normal*, perithecium formation being either delayed or less abundant; (4) attempts at inbreeding have been entirely unsuccessful to date (save in one *purple*  $\times$  *purple* mating), neither perithecia nor perithecial fundaments being produced in matings of variant strains bearing opposite sex-reaction

factors; and (5) all have shown either complete reversion to the *normal* or variation "in the direction" of the *normal*. These facts strongly indicate that under the environmental conditions which obtained during the work none of the ascospore variants would long be perpetuated in competition with the *normal* strains. The interesting observations concerning the high temperature requirement for maintenance of the *reverta* variant suggest the possibility that in certain environments the mutant strains might be able to compete successfully with the *normal*.

#### SUMMARY

A number of variants which cannot well be explained on the basis of Mendelian segregation of preëxisting genes have arisen as the primary growth from single ascospores isolated from both inbred and hybrid perithecia of *Hypomyces Ipomoeae*.

Hybridization studies have shown the variations, with one possible exception, to have been the result of gene mutation.

The reversion of many of these mutants to the *normal* type, both in the maturation divisions and in vegetative cells, indicates that the mutations have been of the nature of inactivation or alteration, rather than deletion, of the genes.

The observations strongly suggest that gene mutation is favored in the maturation divisions—particularly in heterozygotes. Effects of the mutations appear in some cases to be carried over into the gametophytic cells of the mutants.

Evidence is presented which indicates that under existing environmental conditions the ascospore variants studied would not be perpetuated in competition with the *normal* type.

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## NOTES AND BRIEF ARTICLES

### MYCOLOGICAL SOCIETY OF AMERICA

#### FUNGI COLLECTED AT THE FORAY, AUGUST 1938

As has been reported elsewhere (*Mycologia* 31: 233-234. 1939) the Mycological Foray for 1938 was held at Duchesnay, Quebec, August 23-27. The weather was specially favorable for the development of fungi and collecting was excellent. On account of the small amount of published information concerning the mycological flora of Quebec it was voted to publish a complete list of the fungi collected during the foray and the undersigned committee was appointed to supervise the preparation of the list.

During the foray 836 species and varieties were collected, an unusual number for such a short period. The following list of species has been compiled from reports submitted by the various collectors. The symbols in parenthesis indicate the sources of the reports.

- B = Henry C. Beardslee, Altamonte Springs, Fla.  
Be = Ernst A. Bessey, Michigan State College.  
Br = Jules Brunel, Université de Montréal.  
C = Cornell University group, combining reports of collections by H. H. Whetzel, Thomas Sproston, and H. M. Fitzpatrick.  
G = J. Walton Groves, Ottawa, Ontario.  
H = L. K. Henry, Carnegie Museum, Pittsburgh, Pa.  
Ha = Robert Hagelstein and Joseph H. Rispaud, New York Botanical Garden.  
J = Henry A. C. Jackson, Montreal, Canada.  
M = E. B. Mains, University of Michigan.  
N = Fred J. Seaver, New York Botanical Garden.  
O = L. O. Overholts, Pennsylvania State College.  
P = René Pomerleau, Quebec.  
S = Walter H. Snell, Brown University.  
T = H. S. Jackson and Roy F. Cain, University of Toronto.  
W = C. L. Shear, John A. Stevenson, C. W. Emmons, and A. J. Moyer, Washington, D. C.

MYXOMYCETES: *Arcyria carnea* G. List. (Ha); *A. cinerea* (Bull.) Pers. (Ha); *A. denudata* (L.) Wettst. (G, Ha); *A. ferruginea* Sauter (Ha); *A. incarnata* Pers. (Ha); *A. insignis* Kalchb. & Cooke (Ha); *A. nutans* (Bull.) Grev. (Ha); *A. occidentalis* (Macbr.) List. (Ha); *A. Oerstedtii* Rost. (Ha, T); *A. pomiformis* (Leers) Rost. (Ha); *A. stipata* (Schw.) List. (Ha); *Badhamia affinis* Rost. (Ha); *B. lilacina* (Fr.) Rost. (Ha); *B. magna* Peck (Ha); *B. orbiculata* Rex (Ha); *B. rubiginosa* (Chev.) Rost. (Ha); *Ceratiomyxa fruticulosa* (Muell.) Macbr. (Ha);

*Cienkowskia reticulata* (Alb. & Schw.) Rost. (Ha); *Comatricha aequalis* Peck (Ha); *C. nigra* (Pers.) Schroet. (Ha); *C. pulchella* (Bab.) Rost. (Ha); *C. rubens* List. (Ha); *C. tenerrima* (Curt.) G. List. (Ha); *C. typhoides* (Bull.) Rost. (Ha); *C. typhoides* (Bull.) Rost. var. *similis* (Ha); *Craterium aureum* (Schum.) Rost. (Ha); *C. leucocephalum* (Pers.) Ditm. (Ha, P, T); *C. minutum* (Leers) Fr. (Ha); *Cribraria intricata* Schrad. (Ha); *C. macrocarpa* Schrad. (T); *C. purpurea* Schrad. (Ha); *C. vulgaris* Schrad. (Ha); *Diachea leucopoda* (Bull.) Rost. (Ha); *D. subsessilis* Peck (Ha); *Dictydiaethalium plumbeum* (Schum.) Rost. (Ha); *Dictydium cancellatum* (Batsch) Macbr. (Ha); *Diderma effusum* (Schw.) Morg. (Ha); *D. globosum* Pers. (Ha); *D. hemisphaericum* (Bull.) Hornerh. (Ha); *D. ochraceum* Hoffm. (Ha); *D. Sauteri* (Rost.) Macbr. (Ha); *D. spumarioides* Fr. (Ha); *D. testaceum* (Schrad.) Pers. (G, Ha, T); *Didymium anellus* Morg. (Ha); *D. Clavus* (Alb. & Schw.) Rabenh. (Ha); *D. difforme* (Pers.) Duby var. *comatum* (Ha); *D. eximium* Peck (Ha); *D. melanospermum* (Pers.) Macbr. (Ha, T); *D. nigripes* (Link) Fr. (Ha); *D. squamulosum* (Alb. & Schw.) Fr. (Ha); *Enerthenema papillatum* (Pers.) Rost. (Ha); *Fuligo muscorum* Alb. & Schw. (C, Ha); *F. septica* (L.) Weber var. *candida* (Ha); *F. septica* (L.) Weber var. *rufa* (Ha); *Hemitrichia abietina* (Wig.) List. (Ha); *H. clavata* (Pers.) Rost. (Ha); *H. serpula* (Scop.) Rost. (Ha, T); *H. vesparium* (Batsch) Macbr. (Ha); *Lamproderma arcyriionema* Rost. (Ha); *L. scintillans* (Berk. & Br.) Morg. (Ha); *L. violaceum* (Fr.) Rost. (Ha); *Leocarpus fragilis* (Dicks.) Rost. (Br, G, H, Ha, T); *Licea minema* Fr. (T); *Lycogala epidendrum* (L.) Fr. (Ha); *L. exiguum* Morg. (Ha); *L. flavo-fuscum* (Ehrenb.) Rost. (Ha); *Margarita metallica* (Berk. & Br.) List. (Ha); *Mucilago spongiosa* (Leyss.) Morg. (Ha); *Oligonema nitens* (Lib.) Rost. (Ha); *Perichaena chrysosperma* (Currey) List. (Ha); *P. corticalis* (Batsch) Rost. (Ha); *P. depressa* Lib. (Ha); *Physarum aureum* Brandza (Ha); *P. auriscalpium* Cooke (Ha); *P. bogoriense* Racib. (Ha); *P. cinereum* (Batsch) Pers. (Ha); *P. citrinellum* Peck (Ha); *P. confertum* Macbr. (Ha); *P. conglomeratum* Rost. (Ha); *P. contextum* Pers. (Ha, T); *P. contextum* Pers. var. *Mortoni* (Ha); *P. flavicomum* Berk. (Ha); *P. galbeum* Wing. (Ha); *P. globuliferum* (Bull.) Pers. (Ha); *P. lateritium* (Berk. & Rav.) Morg. (Ha); *P. leucopus* Link (Ha); *P. Listeri* Macbr. (Ha); *P. luteolum* Peck (Ha); *P. melleum* (Berk. & Br.) Mass. (Ha); *P. murinum* List. (Ha); *P. notabile* Macbr. (Ha, T); *P. nutans* Pers. (Ha, T); *P. nutans* Pers. var. *leucophaeum* (Ha); *P. oblatum* Macbr. (Ha); *P. penetrans* Rex (Ha); *P. psittacinum* Ditm. (Ha); *P. pulcherrimum* Berk. & Rav. (Ha); *P. pulcherripes* Peck (Ha); *P. pusillum* (Berk. & Curt.) List. (Ha); *P. rubiginosum* Fr. (Ha); *P. sessile* Brandza (Ha); *P. sinuosum* (Bull.) Weinm. (Ha); *P. sulphureum* Alb. & Schw. (Ha); *P. tenerum* Rex (Ha); *P. virescens* Ditm. (Ha); *P. viride* (Bull.) Pers. (Ha); *P. viride* (Bull.) Pers. var. *aurantium* (Ha); *P. Wingatense* Macbr. (Ha); *Stemonitis axifera* (Bull.) Macbr. var. *Smithii* (Ha); *S. fusca* Roth (Ha); *S. trechispora* Macbr. (Ha); *Trichia Botrytis* (Gmel.) Pers. (Ha); *T. contorta* (Ditm.) Rost. (Ha, T); *T. contorta* (Ditm.) Rost. var. *inconspicua* (Ha); *T. decipiens* (Pers.) Macbr. (Ha); *T. erecta* Rex (Ha); *T. favoginea* (Batsch) Pers. (T); *T. persimilis* Karst. (Ha); *T. scabra* Rost. (Ha, T); *T. subfusca* Rex (Ha); *Tubifera Casparyi* (Rost.) Macbr. (Ha); *T. ferruginosa* (Batsch) Gmel. (Ha).

PHYCOMYCETES: *Bremia Lactucae* Regel. (O); *Endogone pisiformis* Link (C, G, M, O, T, W); *Mucor sylvaticus* Hagem (Be); *Pilobolus umbonatus* Buller (T); *Plasmopara Viburni* Peck (C, T); *Pythiomorpha gonapodyoides* Petersen (Be); *Saprolegnia litoralis* Coker (Be); *Synchytrium aureum* Schroet. (Be).



DISCOMYCETES: *Apostemidium Guernisaci* (Cr.) Boud. (T); *Ascobolus carbonarius* Karst. (N); *A. immersus* Pers. (T); *A. viridulus* Phill. & Plowr. (T) *Ascoalexys Abietis* Naumov (G); *Ascophanus carneus* (Pers.) Boud. (T); *A. lacteus* (Cooke & Phill.) Sacc. (T); *Ascotremella faginea* (Peck) Seaver (T); *Belonidium basitrichum* Sacc. (W); *Calycina macrospora* (Peck) Seaver (C, N, O, T, W); *Catinella nigro-olivacea* (Schw.) Durand (C, O); *Cenangium furfuraceum* (Roth) DeNot. (G); *Chlorociboria aeruginosa* (Oed.) Seaver (H, N); *C. versiformis* (Pers.) Seaver (C, N, O, W); *Chlorosplenium aeruginascens* (Nyl.) Karst. (C, O, T, W); *Coryne sarcoides* (Jacq.) Tul. (Br, O, P, T); *Cudonia circinans* (Pers.) Fr. (G, T, W); *C. lutea* (Peck) Sacc. (G, M, N, O, P); *Dasy-scypha Agassizii* (Berk. & Curt.) Sacc. (Br, G, H, J, N, O, P, T, W); *D. arida* (Phill.) Sacc. (G); *D. nivea* (Hedw.) Sacc. (N); *Dermatea acerina* (Peck) Rehm (C, G, O); *D. Ariae* (Pers.) Tul. (G, W); *D. balsamea* (Peck) Seaver (Br, G, P, T, W); *D. Cerasi* (Pers.) Fr. (G); *D. molliuscula* (Schroet.) Cash (Br, G, O, T, W); *D. Peckiana* (Rehm) Groves (G); *Durandiella Nemopanthis* (Peck) Groves (G); *Geoglossum alveolatum* Durand (T); *G. glabrum* Pers. (J, M, O, T, W); *G. nigrum* Cooke (T); *Gloeoglossum difforme* (Fr.) Durand (M); *G. glutinosum* (Pers.) Durand (C, N, T); *Godronia Urceolus* var. *confertus* Hone (G); *Godroniopsis Nemopanthis* Groves (G, W); *Helotium citrinum* (Hedw.) Fr. (G, N, O, T, W); *H. epiphyllum* (Pers.) Fr. (O, W); *H. fastidiosum* Peck (C); *H. herbarum* (Pers.) Fr. (W); *H. immutabile* Fuckel (T); *H. phyllophyllum* (Desm.) Karst. (C, T); *H. Scutula* (Pers.) Karst. (C, G, W); *Helvella crispa* (Scop.) Fr. (J); *H. elastica* (Bull.) Fr. (Br); *H. Mitra* L. (Br, G, H, J); *Lamprospora Crec'hqueraultii* (Crouan) Boud. (N); *Lasiobolus equinus* (Müll.) Karst. (T); *Leotia chlorocephala* Schw. (G, J, M, N, P, T, W); *L. lubrica* (Scop.) Pers. (Br, C, G, H, J, N, O, P, T, W); *L. stipitata* (Bosc.) Schroet. (Br, G, H, J, M, O, T); *Macropodia macropus* (Pers.) Fuckel (W); *Microglossum rufum* (Schw.) Underw. (J, N, W); *Mitrula irregularis* (Peck) Durand (G); *Mollisia uda* (Pers.) Gill. (W); *Ombrophila lilacina* (Wulf.) Karst. (T); *Orbilbia botulisporea* Höhn. (T); *O. epipora* Karst. (T); *Otidea grandis* (Pers.) Mass. (Br, N, W); *O. leporina* (Batsch) Fuckel (G, H, O, T); *Patella alba* (Schaeff.) Seaver (G, W); *P. coprinaria* (Cooke) Seaver (N, T, W); *P. gregaria* (Rehm) Seaver (T); *P. ovilla* (Peck) Seaver (T); *P. scutellata* (L.) Morg. (H, N, O, P, T, W); *Paxina fusicarpa* (Ger.) Seaver (C); *P. hispida* (Schaeff.) Seaver (Br, C, G, H, J, O); *Pezicula acericola* (Peck) Sacc. (C, G, H, O, P, T, W); *P. carnea* (Cooke & Ell.) Rehm (G, W); *P. corylina* Groves (G); *P. minuta* Peck (G, T); *P. pruinosa* Farl. (G); *P. rosella* Rehm (G); *Peziza badia* Pers. (Br); *P. brun-neoatra* Desm. (H); *Pezizella Lythri* (Desm.) Shear & Dodge (W); *Plicariella murina* (Fuckel) Rehm (T); *Podophacidium xanthomelum* (Pers.) Kavina (C, N, T); *Propolis faginea* (Schröd.) Karst. (G, W); *Ryparobius crustaceus* (Fuckel) Rehm (T); *R. monascus* Mouton (T); *R. sexdecimsporus* (Crouan) Sacc. (T); *Saccobolus depauperatus* (Berk. & Br.) Phill. (T); *S. Kerverni* (Crouan) Boud. (T); (G, H, T); *Spathularia clavata* (Schaeff.) Sacc. (J); *S. velutipes* Cooke & Farl. (O, P, T); *Thecotheus Pelletieri* (Crouan) Boud. (T); *Trichoglossum hirsutum* (Pers.) Boud. (H, T, W); *T. velutipes* (Peck) Durand (M, P); *Tympanis alnea* (Pers.) Fr. (G); *T. fasciculata* Schw. (G, T); *T. Pinastri* Am. auct. (G, W); *T. populina* (Fuckel) Sacc. (W); *T. saligna* Tode (G).

PYRENOMYCETES: *Acrospermum cuneolum* Dearn. & House (O, T); *Bertia*

*moriformis* (Tode) DeNot. (W); *Bombardia arachnoidea* (Niessl) Cain (T); *B. coprophila* (Fr.) Kirsch. (T, W); *Claviceps microcephala* (Wallr.) Tul. (Be, T, W); *Coniochaeta discospora* (Auersw.) Cain (T); *C. Hansenii* (Oud.) Cain (T); *C. leucoplaca* (Berk. & Rav.) Cain (T); *C. scatigena* (Berk. & Br.) Cain (T); *Cordyceps capitata* L. (W); *C. clavulata* (Schw.) Ellis & Ev. (C, M, N, O, P, T, W); *C. militaris* (L.) Link (Br, C, G, H, J, M, N, O, T, W); *C. ophioglossoides* (Ehrh.) Link. (Br, C, G, H, J, M, N, O, P, T, W); *Cryptospora suffusa* (Fr.) Tul. (G); *Cucurbitaria parasitica* (Pass.) Berl. (W); *Daldinia concentrica* (Bolt.) Ces. & DeNot. (J, W); *D. vernicosa* (Schw.) Ces. & DeNot. (Br, H); *Delitschia bisporula* (Crouan) Hans. (T); *D. didyma* Auersw. (T); *D. Marchalii* Berl. & Vogl. (T); *D. timagamensis* Cain (T); *Dialonectria sanguinea* (Bolt.) Cooke (T); *Diaporthe impulsu* (C. & P.) Sacc. (G, W); *D. tessera* (Fr.) Fuckel (W); *Diatrype Stigma* (Hoff.) DeNot. (W); *D. virescens* (Schw.) Ellis & Ev. (N, W); *Dibotryon morbosum* (Schw.) Th. & Sy. (G, O, W); *Dothiora Sorbi* (Wahlbg.) Rem. (W); *Erysiphe Galeopsidis* DC. (O); *Eutypella Sorbi* (Schm.) Sacc. (G); *Fenestella vestita* (Fr.) Sacc. (W); *Gelasinospora tetrasperma* Dowding (T); *Gnomoniella Coryli* (Batsch) Sacc. (Be, M, T, W); *Hypocrea aurantiaca* Peck (G); *H. citrina* (Pers.) Fr. (T); *H. patella* Cooke & Peck (G, N, W); *H. pulvinata* Fuckel (T); *H. rufa* (Pers.) Fr. (O, T, W); *Hypocreopsis lichenoides* (Tode) Seaver (T); *Hypomyces apiculatus* (Peck) Seaver. (C, M, W); *H. chrysospermus* (Bull.) Tul. (O); *H. hyalinus* (Schw.) Tul. (J, O, P); *H. Lactiflorum* (Schw.) Tul. (Br, C, G, H, J, N, O, T); *Hypoxylon caries* (Schw.) Sacc. (W); *H. cohaerens* (Pers.) Fr. (P, T, W); *H. fuscum* (Pers.) Fr. (W); *H. deustum* (Hoffm.) Grév. (T); *H. multiforme* Fr. (N, O, W); *H. rubiginosum* (Pers.) Fr. (T); *H. serpens* (Pers.) Fr. (T); *Lasio-sphaeria hirsuta* (Fr.) Ces. & DeNot. (T); *L. muscicola* DeNot. (T); *L. ovina* (Pers.) Ces. & DeNot. (T); *L. Sphagni* Delacr. (C, W); *Leptosphaeria lycopodiicola* (Peck) Sacc. (W); *L. subconica* (Cooke & Peck) Sacc. (W); *Leptospora canescens* (Pers.) Wint. (T); *Linospora* sp. (C); *Lophiostoma triseptatum* Peck (W); *Lophotrichia viridicoma* (Cooke & Peck) Kauff. (T); *Melanomma pulvis-pyrus* (Pers.) Fuckel (W); *Mycosphaerella colorata* (Peck) Earle (Be); *Nectria cinnabarina* (Tode) Fr. (G, O, T, W); *N. Cucurbitula* Sacc. (G); *N. ditissima* Tul. (Br); *Nummularia discreta* Schw. (W); *Perisporium vulgare* Corda (T); *Phaeocryptopus nudus* (Peck) Petr. (G, O, T, W); *Phomatospora hyalina* (Griff.) Cain (T); *Podosphaeria Oxyacanthae* (DC.) deBary (Be); *Rosellinia mammiformis* (Pers.) Ces. & DeNot. (G); *R. pulveracea* (Ehr.) Fuckel (W); *Scolecconectria balsamea* (Cooke & Peck) Seaver (W); *S. scolecospora* (Bref.) Seaver (W); *Sordaria appendiculata* Auersw. (T); *S. anserina* (Ces.) Wint. (T); *S. araneosa* Cain (T); *S. barbata* Hans. (T); *S. carbonaria* (Phill. & Plowr.) Sacc. (T); *S. cervina* Cain (T); *S. curvicolla* Wint. (T); *S. curvula* deBary (T); *S. decipiens* Wint. (T); *S. dubia* Hans. (T); *S. fimicola* (Rob.) Ces. & DeNot. (T); *S. fimiseda* Ces. & DeNot. (T); *S. glutinans* Cain (T); *S. leporina* Cain (T); *S. macrospora* Auersw. (T); *S. minima* Sacc. & Speg. (T); *S. minuta* Fuckel (T); *S. perplexens* Cain (T); *S. pleiospora* Wint. (T); *S. setosa* Wint. (T); *S. tetraspora* Wint. (T); *S. vestita* Zopf (T); *S. zygospora* Speg. (T); *Sporormia ambigua* Niessl (T); *S. bipartis* Cain (T); *S. intermedia* Auersw. (T); *S. leporina* Niessl (T); *S. longispora* Cain (T); *S. minima* Auersw. (T); *S. muskokensis* Cain (T); *S. obliquisepta* Speg. (T); *S. octomera* Auersw. (T); *S. splendens* Cain (T); *Ustulina vulgaris* Tul. (P, W); *Valsa Abietis* Fr. (T, W); *V. nivea* (Hoff.)

Fr. (O); *Xylaria castorea* Berk. (T); *X. corniformis* Fr. (G); *X. filiformis* (Alb. & Schw.) Fr. (C, T, W); *X. longipes* Nitsch. (T); *X. polymorpha* (Pers.) Grév. (Br, J, O, P, W).

OTHER ASCOMYCETES: *Agrium rufum* (Pers.) Fr. (W); *Coccomyces coronatus* (Schw.) Rehm (C); *Cryptomyces Pieridis* (Reb.) Rehm (Br, C, P, W); *Dimersporium pulchrum* Sacc. (W); *Elaphomyces muricatus* Fr. (T); *E. variegatus* Vitt. (C, P); *Hypoderma rufilabrum* (Berk. & Curt.) Duby (O); *Onygena equina* Pers. (Br, G, J, W); *Propolis faginea* (Schr.) Karst. (N); *Rhytisma acerinum* (Pers.) Fr. (W); *R. Andromedae* (Pers.) Fr. (M); *R. Ilicis-canadensis* Schw. (Br, C, G, O); *R. salicina* (Pers.) Fr. (N, O, W); *R. Vaccinii* (Schw.) Fr. (W); *Taphrina Robinsoniana* Gies. (C, G, W).

LOWER BASIDIOMYCETES: *Auricularia Auricula-Judae* (Fr.) Schroet. (Br, C, G, H, O, P, W); *Calocera cornea* (Batsch.) Fr. (H, O, P, W); *Dacryomyces aurantius* (Schw.) Farl. (H, W); *D. Ellisii* Coker (O); *D. palmatus* (Schw.) Bres. (J, O, P, T); *Exidia glandulosa* (Bull.) Fr. (O, T); *E. recisa* (Bull.) Fr. (W); *Exobasidium Vaccinii* (Fuckel) Wor. (C); *Femsjonia luteoalba* Fr. (Br, H, O, T, W); *Guepinia Peziza* Tul. (O); *Heterochaetella dubia* Bourd. & Galz. (T); *Hormomyces fragiformis* Cooke (O, W); *Naematelia nucleata* (Schw.) Fr. (O, P, T); *Pilacreia faginea* (Fr.) Berk. & Br. (C, O, P, W); *Sebacina caesio-cinerea* (Höhn. & Litsch.) Rogers (T); *S. Eyrei* Wakef. (T); *S. incrustans* (Pers.) Tul. (Br, H); *S. subilacina* Martin (T); *Tremella foliacea* var. *succinea* (Pers.) Neuh. (T); *T. frondosa* Fr. (G, O); *Tremellodendron candidum* (Schw.) Atk. (H); *T. merismatoides* (Schw.) Burt (W); *T. pallidum* (Schw.) Burt (O, T); *Tremellodon gelatinosum* (Scop.) Fr. (Br, C, G, H, J, O, T, W); *Tulasnella pruinosus* Bourd. & Galz. (T).

USTILAGINALES AND UREDINALES: *Calyptospora Goeppertiana* Kühn (Be, Br, C, H, M, O); *Chrysomyxa Cassandrae* (Peck & Clin.) Tranz. (M); *C. Pyrolae* (DC.) Rostr. (M); *Cintractia externa* (Griff.) Clint. (W); *Coleosporium Solidaginis* (Schw.) Thuem. (M, W); *Melampsora Abieti-capraearum* Tub. (O, W); *M. Ribesii-purpureae* Kleb. (W); *Melampsorella Cerastii* (Pers.) Schroet. (Br, J, T, W); *Puccinia Circaeae* Pers. (T); *P. extensicola* Plowr. (W); *P. Heucherae* (Schw.) Dietel (O); *P. porphyrogenita* Curt. (G, O, W); *P. Violae* (Schum.) DC. (C, O); *Pucciniastrum Agrimoniae* (Schw.) Tranz. (O); *P. Epilobii* Otth (Be, O, T, W); *Sphacelotheca Hydropiperis* (Schum.) deBary (C); *Uredinopsis macrosperma* (Cooke) Magn. (Be); *U. Osmundae* Magn. (C, M, O, T, W); *U. mirabilis* (Peck) Magn. (W); *Uromyces Junci* (Desm.) L. Tul. (W).

THELEPHORACEAE: *Aleurodiscus acerinus* (Pers.) Höhn. & Litsch. (O); *A. acerinus alliaceus* (Quél.) Bourd. & Galz. (T); *A. amorphus* (Pers.) Rabenh. (C, G, O, T, W); *A. canadensis* Jackson (O); *A. Farlowii* Burt (G, M, O, T); *A. griseo-canus* (Bres.) Höhn. & Litsch. (T); *A. penicillatus* Burt (T); *Coniophora cerebella* Pers. (T); *Corticium anceps* (Bres. & Syd.) Gregor (C, O, P, T); *C. bombycinum* (Sommerf.) Bres. (T); *C. centrifugum* (Lév.) Bres. (T); *C. confine* Bourd. & Galz. (T); *C. confluens* Fr. (T); *C. coronatum* (Schroet.) Höhn. & Litsch. (T); *C. coronilla* Höhn. (T); *C. crustaceum* (Karst.) Höhn. & Litsch. (T); *C. deflectens* Karst. (T); *C. flavescens* (Bon.) Wint. (T); *C. galactinum* (Fr.) Burt (O, T); *C. hydnans* (Schw.) Burt (G, T); *C. investiens* (Schw.) Bres. (Br, O, P); *C. laeve* Pers. (T); *C. microsporum* (Karst.) Bourd. & Galz. (T); *C. porosum* Berk. & Curt. (T); *C. roseocreteum* Bres. (T); *C. roseum*

Pers. (G); *C. sphaerosporum* Maire? (T); *C. stellulatum* Bourd. & Galz. (T); *C. subcoronatum* Höhn. & Litsch. (T); *C. subpallidulum* Litsch. (T); *C. vagum* Berk. & Curt. (T); *Craterellus clavatus* Pers. (T); *C. cristatus* Kauff. (O, T); *C. lutescens* (Pers.) Fr. (H); *C. taxophilus* Thom (Br, C, J, M, O, P, W); *Cyphella arachnoidea* Peck? (T); *C. fasciculata* (Schw.) Berk. & Curt. (G, O, T); *Cytidia salicina* (Fr.) Burt (G, T); *Gloeocystidium furfuraceum* (Bres.) Höhn. & Litsch. (T); *Hymenochaete agglutinans* Ellis (T, W); *H. arida* Karst.? (T); *H. corrugata* (Fr.) Lév. (O, T); *H. rubiginosa* (Dicks.) Lév. (H); *H. tabacina* (Sow.) Lév. (Br, O, P, T, W); *Hypochnus fumosus* Fr. (T); *H. isabelinus* Fr. (T); *H. umbrinus* (Fr.) Burt (T); *Peniophora affinis* Burt (T); *P. argillacea* Bres. (T); *P. aurantiaca* Bres. (O, T); *P. byssoidea* (Pers.) Höhn. & Litsch. (T); *P. carnosa* Burt (T); *P. cinerea* (Pers.) Cooke (O, T); *P. gigantea* (Fr.) Mass. (T); *P. glebulosa* Bres. (G, T); *P. laevigata* (Fr.) Mass. (O); *P. laevis* (Fr.) Höhn. & Litsch. (T); *P. longispora* (Pat.) Höhn. (T); *P. miniata* (Berk.) Burt (G); *P. nuda* (Fr.) Bres. (T); *P. pallidula* Bres. (T); *P. pubera* (Fr.) Sacc. (T); *P. Sambuci* (Pers.) Burt (T); *P. sanguinea* (Fr.) Bres. (T); *P. sordidella* Höhn. & Litsch. (T); *P. tenue* (Pat.) Mass.? (T); *P. viticola* (Schw.) Höhn. & Litsch. (T); *Stereum fasciatum* Schw. (Br, G, H, O, T, W); *S. Murrayi* (Berk. & Curt.) Burt (O, T, W); *S. roseo-carneum* (Schw.) Fr. (G, O, T); *S. rufum* Fr. (W); *S. sanguinolentum* Alb. & Schw. (G, J, O, P, T, W); *Thelephora intybacea* (Pers.) Fr. (H, T, W); *T. multipartita* Schw. (O, T); *T. palmata* (Scop.) Fr. (Br, C, G); *T. terrestris* (Ehrh.) Fr. (T).

CLAVARIACEAE: *Clavaria apiculata* Fr. (H); *C. appalachiensis* Coker (G, O); *C. contorta* (Holmsk.) Fr. (O); *C. cristata* (Holmsk.) Fr. (Br, G, H, O, P, T); *C. crocea* (Pers.) Fr. (H, J, O); *C. flava* Schaeff. (H); *C. formosa* Pers. (T); *C. fusiformis* Sowerby (Br, G, H, O, T, W); *C. helveola* (Pers.) Fr. (O); *C. Kunzei* Fr. (Br, H, O, P, T); *C. ligula* (Schaeff.) Fr. (Br, H, O, P, W); *C. longicaulis* Peck. (J, O, P); *C. mucida* Pers. (J); *C. muscoides* L. (G, J, O, T); *C. ornatipes* Peck (H, O, P, T); *C. pistillaris* (L.) Fr. (O); *C. pulchra* Peck (O, T); *C. stricta* (Pers.) Fr. (H, J, O); *Physalacria inflata* (Schw.) Peck (C, J, O, P, T, W); *Pistillaria clavulata* Ellis (W).

HYDNACEAE: *Asterodon ferruginosum* Pat. (O, T); *Hydnum albo-nigrum* Peck (B, J, W); *H. cyaneotinctum* Peck (B, Br, O); *H. ferrugineum* Fr. (B); *H. graveolens* Delast. (T); *H. imbricatum* (L.) Fr. (B); *H. laciniatum* Leers. (O, W); *H. ochraceum* (Pers.) Fr. (Br, G, H, J, O, P, T, W); *H. repandum* Fr. (B, Br, G, H, O, W); *H. scrobiculatum* Fr. (B, H, P); *H. vellereum* Peck (B, O, W); *H. zonatum* (Batsch) Fr. (B, G, H, J, O, T, W); *Mucronella aggregata* Fr. (T); *Odonia alutacea* (Fr.) Bourd. & Galz. (T); *O. aspera* (Fr.) Bourd. & Galz. (T); *O. bicolor* (Alb. & Schw.) Bres. (T); *O. crustosa* (Fr.) Quél. (O, T); *O. fusco-atra* (Fr.) Bres. (T); *O. hydroides* (Cooke & Mass.) Höhn. (T); *O. pruinosa* Bres. (T); *Phlebia merismoides* Fr. (O).

BOLETACEAE: *Boletinus pictus* Peck (H, J, O, S, T, W); *Boletus americanus* Peck (J, S); *B. badius* Fr. (J, O, S); *B. castaneus* (Bull.) Fr. (J, O, P, S); *B. chromapes* Frost (J, S); *B. chrysenteron* (Bull.) Fr. (G, J, S, T); *B. cyanescens* (Bull.) Fr. (Br, G, H, J, O, P, S, W); *B. edulis* (Bull.) Fr. (Br, H, J, O, S); *B. felleus* (Bull.) Fr. (Br, J, S, T); *B. gracilis* Peck (S); *B. granulatus* (L.) Fr. (G, J, H, S); *B. indecicus* Peck (G, J, S); *B. niveus* Fr. (S); *B. piperatus* (Bull.) Fr. (Br, G, H, J, S, T); *B. placidus* Bon. (H, J, S); *B. rubinellus* Peck (Br, H, J, O, S, T); *B. scaber* (Bull.) Fr. (Br, G, H, J, S, T); *B. subglabripes* Peck

(H, J, S, T); *B. subtomentosus* (L.) Fr. (Br, G, O, S, T); *B. versipellis* Fr. (H, J, S, T); *B. viscidus* Fr. (J, S); *Strobilomyces strobilaceus* (Scop.) Berk. (G, J, S).

POLYPORACEAE: *Daedalea confragosa* (Bolt.) Fr. (Br, G, H, O, W); *D. unicolor* (Bull.) Fr. (Br, G, H, W); *Favolus canadensis* Kl. (Br, O, P); *Fomes annosus* (Fr.) Cooke (Br, O, P); *F. applanatus* (Pers.) Gill. (Br, H, W); *F. conchatus* (Pers.) Karst. (Br, O); *F. connatus* (Weinm.) Gill. (Br, G, H, J, O, P, T, W); *F. fomentarius* (L.) Gill. (Br, H, W); *F. igniarius* (L.) Gill. (Br, G, W); *F. igniarius* var. *laevigatus* (Fr.) Overh. (Br, O, P, W); *F. Pini* (Thore) Karst. (W); *F. Pini* var. *Abietis* (Karst.) Overh. (O); *F. pinicola* (Sw.) Cooke (Br, O, W); *F. subroseus* (Weir) Overh. (O); *Lenzites betulina* (L.) Fr. (W); *L. saepiaria* (Wulf.) Fr. (C, G, H, O, T, W); *Merulius ceracellus* Berk. & Curt.? (T); *M. fugax* Fr. (T); *M. niveus* Fr. (T); *M. tremellosus* (Schrad.) Fr. (O, P, W); *Polyporus abietinus* (Dicks.) Fr. (Br, H, O, P, W); *P. adustus* (Willd.) Fr. (H); *P. albellus* Peck (Br, H, J, O, P, W); *P. balsameus* Peck (Br); *P. betulinus* (Bull.) Fr. (G, H, O, T); *P. brumalis* (Pers.) Fr. (P); *P. caesius* (Schrad.) Fr. (O); *P. cinnabarinus* (Jacq.) Fr. (Br, H, O); *P. cinnamomeus* (Jacq.) Sacc. (G, O); *P. circinatus* Fr. (C, G); *P. cristatus* (Pers.) Fr. (W); *P. elegans* (Bull.) Fr. (Br, H, P, T, W); *P. fomicola* Berk. & Curt. (O); *P. fumidiceps* Atk. (H); *P. galactinus* Berk. (G, O); *P. glomeratus* Peck (H, O, T, W); *P. guttulatus* Peck (H, O); *P. hirtus* Quél. (J, O, T); *P. hirsutus* (Wulf.) Fr. (Br); *P. nidulans* Fr. (O, W); *P. pargamensis* Fr. (Br, H, W); *P. perennis* (L.) Fr. (C, H, T, W); *P. picipes* Fr. (G, H, O, W); *P. planellus* (Murr.) Overh. (W); *P. pubescens* (Schum.) Fr. (Br, J, P); *P. resinosis* (Schrad.) Fr. (H, O, T); *P. resinosis* var. *benzoinus* Overh. (G); *P. Schweinitzii* Fr. (C, G, O, W); *P. semipileatus* Peck (G, O, P, T); *P. semisupinus* Berk. & Curt. (G, O, P, T, W); *P. tephroleucus* Fr. (H); *P. Tulipiferae* (Schw.) Overh. (Br, H, O, W); *P. versicolor* (L.) Fr. (Br, H, W); *Poria candidissima* (Schw.) Cooke (T); *P. corticola* (Fr.) Cooke (H, J, T); *P. ferrea* Pers. (O); *P. ferruginosa* (Schrad.) Fr. (J, T, W); *P. fimbriata* (Pers.) Overh. (O); *P. lenis* Karst. (O); *P. medullaripanis* (Pers.) Cooke (T); *P. nigrescens* Bres. (O); *P. prunicola* (Murr.) Sacc. & Trott. (O); *P. punctata* Fr. (H, O); *P. rufa* (Schrad.) Fr. (T); *P. selecta* Karst. (T); *P. spissa* Schw. (T); *P. subacida* (Peck) Sacc. (G); *Solenia anomala* (Pers.) Fuckel. (W); *S. candida* (Hoffm.) Fr. (O); *Trametes heteromorpha* (Fr.) Lloyd (Br, C, O); *T. mollis* (Sommerf.) Fr. (O, P, W).

AGARICACEAE: *Amanita brunnescens* Atk. (B); *A. flavoconia* Atk. (Br, G, H, O, T); *A. Frostiana* Peck (B); *A. muscaria* (L.) Fr. (B, G, H); *A. phalloides* Fr. (Br, J); *A. rubescens* Fr. (B, Br, O); *A. verna* Fr. (B, Br); *Amanitopsis strangulata* Fr. (J); *A. vaginata* var. *fulva* Sacc. (B, Br, H, O, W); *A. vaginata* var. *livida* Peck (H); *Armillaria mellea* Fr. (B); *Cantharellus aurantiacus* Fr. (H, J, O); *C. cibarius* Fr. (Br, G, H, J, O, W); *C. clavatus* Fr. (G, J, O); *C. floccosus* Schw. (G, H, J, P); *C. infundibuliformis* (Scop.) Fr. (Br, G, H, J, O, P); *C. umbonatus* Fr. (G, J, P); *Clitocybe albissima* Peck (J, O, P); *C. catina* Fr. (H); *C. clavipes* Fr. (G, H, J, O); *C. decora* Fr. (B, G); *C. ectypoides* Peck (B, G, H, J, O); *C. infundibuliformis* (Schaeff.) Fr. (Br, G, H, J, O); *C. laccata* (Scop.) Fr. (Br, H, O, P); *C. ochropurpurea* Berk. (W); *C. odora* (Bull.) Fr. (G, H, J, O); *Clitopilus novaboracensis* Peck (O); *C. orcellus* Fr. (H, O); *C. prunulus* Fr. (O); *Collybia abundans* Peck (B, Br, G, H, J, O, P); *C. acervata* Fr. (B, G, J, P); *C. butyracea* Fr. (Br, H, P); *C. cirrhata* Fr. (H, J, W); *C. coloreta*

Peck (H, J, P); *C. confluens* Fr. (B, Br, H, J, O, W); *C. dryophila* (Bull.) Fr. (B, H, J, O, P); *C. familia* Peck (B); *C. platyphylla* Fr. (B, Br, H, O); *C. radicata* (Relh.) Fr. (B, Br, G, J, O, P, W); *C. radicata* var. *furfuracea* Peck (H); *C. succosa* Peck (B); *C. tuberosa* Fr. (B, Br, G, H, J, O, P, T, W); *Coprinus micaceus* Fr. (H, J); *Cortinarius albobolaceus* Fr. (Br, G, J, P); *C. anomalus* Fr. (O); *C. armillatus* Fr. (Br, G, H, O); *C. cinnabarinus* Fr. (G); *C. cinnamomeus* Fr. (G, H, J); *C. distans* Peck (H); *C. mammosus* Kauff. (H); *C. sanguineus* Fr. (H, J); *C. semisanguineus* (Fr.) Kauff. (H, J); *C. violaceus* (L.) Fr. (G, H, J, O, P, T); *Crepidotus fulvotomentosus* Peck (H); *C. malachius* Berk. & Curt. (O); *Entoloma salmoneum* Peck (B, G, J, T); *E. speculum* Fr. (G); *E. cuspidatum* Peck (B); *E. sericellum* Fr. (B); *E. strictius* (Peck) Sacc. (G, H, J, O); *Flammula geminella* Peck (G, H, J, O); *F. fusa* (Batsch) Fr. (B); *F. sapinea* Fr. (B); *F. spumosa* Fr. (G, T); *Galera hyphnorum* Fr. (H); *Hygrophorus Cantharellus* Schw. (G, H); *H. ceraceus* Fr. (H, J); *H. conicus* (Scop.) Fr. (B, G, O); *H. cuspidatus* Peck (B); *H. marginatus* Peck (B, Br, G, H, O, P); *H. miniatus* Fr. (Br, J); *H. nitidus* Berk. & Curt. (G, H, J); *H. pallidus* Peck (B, J); *H. Peckii* Atk. (H); *H. pratensis* Fr. (B, H); *H. psitticinus* Fr. (G); *H. puniceus* Fr. (G, J); *H. unguinosus* Fr. (H); *Hypholoma sublateralium* (Bull.) Fr. (O, P); *Inocybe geophylla* Fr. (B); *I. Hystrix* Fr. (B, J, O); *I. lacera* (Fr.) Karst. (H); *I. leptophylla* Atk. (O); *Lactarius affinis* Peck (Br, G, H, O); *L. camphoratus* (Bull.) Fr. (B, Br, G, H, O, P); *L. chrysorheus* Fr. (B, G); *L. cilicioides* Fr. (B); *L. deceptivus* Peck (B, Br, G, O, T); *L. deliciosus* (L.) Fr. (G, H, J, O); *L. fuliginosus* Fr. (H, O); *L. Gerardii* Peck (G, O); *L. glyciosmus* Fr. (O); *L. griseus* Peck (B, Br, G, H, J, O, P); *L. helvus* Fr. (B, P); *L. hygrophoroides* Berk. & Curt. (B, H, O, P); *L. lignyotus* Fr. (B, Br, G, H, O, T); *L. luteolus* Peck (G, O, T); *L. mucidus* Burl. (H, P); *L. pyrogalus* Fr. (H, J); *L. representaneus* Britz. (B); *L. rufus* (Scop.) Fr. (O); *L. scrobiculatus* Fr. (J, O); *L. subdulcis* Peck (B, Br, G, H, J, O, P); *L. theiogalus* Fr. (Br, G, H, O); *L. torminosus* Fr. (G, H); *L. trivialis* Fr. (B, G); *L. turpis* Fr. (B, Br, G, H, J, O, P, T); *L. uvidus* Fr. (G, H); *L. vellereus* Fr. (H, O, P); *L. volemus* Fr. (B); *Lentinus cochleatus* Fr. (Br, O, T); *L. haematopus* Berk. (B, J); *L. lepideus* Fr. (G, H, O, W); *L. ursinus* Fr. (W); *Lepiota acerina* Peck (G, J); *L. acutae-squamosa* Fr. (B, G, J); *L. clypeolaria* Fr. (B, Br, G, J, O, P, T); *L. cristata* Fr. (B, G, H, J); *L. fuscosquamea* Peck (W); *L. granosa* Morgan. (G, O); *L. procera* Fr. (B); *Leptonia asperella* Fr. (B, G); *L. grisea* Peck (O); *L. serrulata* Fr. (B); *Marasmius foetidus* (Sow.) Fr. (G, H, O); *M. perforans* (Hoffm.) Fr. (W); *M. rotula* (Scop.) Fr. (O); *M. scorodonius* Fr. (H); *M. siccus* Schw. (Br, H, O, P); *Mycena epipterygia* Fr. (P, T); *M. haematopoda* Fr. (W); *M. Leaiana* Berk. (G, H, O, P, T); *M. pelianthina* Fr. (G, J, O); *M. pura* Fr. (Br, H, P); *M. rosella* Fr. (H); *Naucoria centuncula* Fr. (B); *N. triscopoda* Fr. (B); *Nolanea conica* Peck (B, H); *N. juncea* Fr. (B); *N. mammosa* Fr. (B); *Nyctalis asterophora* Fr. (H); *N. parasitica* (Bull.) Fr. (O); *Omphalia campanella* (Batsch) Fr. (B, G, H, O); *O. epichysium* Fr. (B, G); *O. fibula* Fr. (B, Br, H, P); *Panaeolus campanulatus* Fr. (Br); *Panus patellaris* Fr. (O); *P. salicinus* Peck (T); *P. stypticus* (Bull.) Fr. (Br, J, O, P, W); *Paxillus atrotomentosus* Fr. (G, J); *P. involutus* (Batsch) Fr. (B, Br, G, H, J, O, P); *Pholiota caperata* (Pers.) Fr. (H, O); *P. confragosa* (Bull.) Fr. (B, H, O); *P. erinacella* Peck (B); *P. flammans* (Batsch) Fr. (O, T); *P. squarrosoides* Peck (Br, G, H, O, P, W); *Pleurotus applicatus* Fr. (O, W); *P. ostreatus* (Jacq.) Fr. (Br, O); *Pluteus admirabilis* Peck

(B); *P. cervinus* Fr. (B, H, J); *P. granularis* Peck (B, O); *P. leoninus* Fr. (G, O); *P. longistriatus* Peck (B); *P. nanus* Fr. (G); *P. tomentosulus* Peck (B); *Psalliotia abruptibulba* Peck (G); *P. comtula* Fr. (B); *P. diminutiva* Peck (T); *Psathyra corrugis* Fr. (B); *Russula aeruginea* Lingb. (H); *R. amygdaloides* Kauff. (H); *R. compacta* Peck (B, Br, H); *R. consobrina* Fr. (H); *R. decolorans* Fr. (H); *R. decolorans* var. *rubriceps* Kauff. (H); *R. emetica* Fr. (H); *R. flava* Romell (H, J, O, W); *R. foetens* (Pers.) Fr. (Br, H, O); *R. foetentula* Peck (H); *R. fragilis* Fr. (B, Br, H, P); *R. nigricans* Fr. (B); *R. pectinatoides* Peck (B, H); *R. purpurina* Quél. & Schultz (B, H); *R. sericeo-nitens* Kauff. (G, J); *R. sordida* Peck (H, J, P); *R. squalida* Peck (H); *R. variata* Banning & Peck (B); *Schizophyllum commune* Fr. (W); *Tricholoma albiflavum* Peck (G, O); *T. sejunctum* Fr. (B, G, J); *Trogia crispa* Fr. (Br, G, H, J, O, P, T, W); *Tubaria inquilina* (Fr.) W. S. Smith (B).

ASTEROMYCETES: *Cyathus striatus* Willd. (Br, C, G, H, O, T, W); *Lycoperdon atropurpureum* Vitt. (W); *L. coloratum* Peck (B, O); *L. gemmatum* (Batsch) Fr. (Br, H, O, P); *L. Peckii* Morgan (T); *L. pedicellatum* Peck (B); *L. pyriforme* Schaef. (Br, H, W); *L. umbrinum* Pers. (W); *Scleroderma aurantium* (Vaill.) Pers. (Br, J, O, P, T, W); *Sphaerobolus stellatus* (Tode) Pers. (Br, C, H, O, W).

FUNGI IMPERFECTI: *Cylindrosporium acerinum* (Peck) Dearn. & House (O); *C. saccharinum* Ellis & Ev. (W); *Darlucia Filum* (Biv.) Cast. (O); *Discosia artocreas* (Tode) Fr. (C); *Gelatinosporium abietinum* Peck (W); *G. fulvum* Peck (O); *Glomerularia Corni* Peck (O, T, W); *Graphium giganteum* Peck (G, H, J, O, P, W); *Helicoma Mülleri* Corda (G); *Micropera Sorbi* (Fr.) Sacc. (W); *Myrothecium inundatum* (Tode) Fr. (T); *Phoma Maianthemum* Peck (C); *Ramularia Oxalidis* Farl. (Be); *Sepedonium cervinum* (Ditm.) Fr. (T); *Septonema episphaericum* Peck (W); *Septoria canadensis* Peck (Be); *Sphaeronae-mella fimicola* Marchal (T); *S. glomerulosporum* Peck (T); *Trichoderma lignorum* (Tode) Harz. (W); *Varicosporium Elodeae* Kegel (Be).

LICHENS: *Bacidia Schweinitzii* (Tuck.) Schneid. (T); *B. suffusa* (E. Fries) Schneid. (T); *Cladonia Floerkeana* (E. Fries) Sommerf. (T); *C. gracilis* (L.) Willd. (T); *Graphis scripta* (L.) Ach. (T); *Icmadophila ericetorum* (L.) Zahlbr. (T); *Lecidea granulosa* (Hoffm.) Ach. (T); *L. peliaspisi* (Tuck.) Zahlbr. (T); *L. vernalis* (L.) Ach. (T); *L. viridescens* (Schr.) Ach. (T).

In addition, undescribed species are recognized for *Aleurodiscus*, *Corticium*, *Merulius*, and *Tremella* by H. S. Jackson; for *Ascobolus*, *Bombardia*, *Gelasinospora*, *Microthyrium*, and *Phaeociboria* by R. F. Cain; for *Helicobasidium* and *Platyglora* by G. W. Martin; for *Dermatea*, and *Durandiella* by J. W. Groves; for *Septobasidium* by J. N. Couch.

Committee: E. B. MAINS, *Chairman*  
L. O. OVERHOLTS  
RENÉ POMERLEAU

MONOBLEPHARIS TAYLORI, A REMARKABLE SOIL FUNGUS  
FROM TRINIDAD<sup>1</sup>

Through the kindness of Prof. W. R. Taylor, botanist of the recent Allan Hancock Pacific Expedition, I was able to obtain a number of soil samples from certain Central American and South American localities which were visited by him.

Among the various Phycomycetous fungi which were recovered from water cultures prepared with these dry soil samples, there appeared in material from Trinidad a delicate species of *Monoblepharis* which has proved to be of considerable interest.

From the accompanying description it will be seen that, aside from the small size, there is nothing unusual about the reproductive organs of the fungus. The remarkable feature of this new species is to be found in the behavior of the egg, which, immediately after fusion with the male gamete, emerges from the oogonium and swims away. The single cilium which propels the zygote appears to be that of the male gamete which persists as a functional organ. The zygote after a short period of motility, comes to rest and surrounds itself with a thickened wall.

The small size of the parts and the unique behavior of the zygote mark the fungus as distinct from all known species of the genus.

***Monoblepharis Taylори* sp. nov.**

Mycelium amplum, hyphis tenuibus, flexuosis, ramosis, 2-5  $\mu$  dia. intus reticulate vacuolatis; sporangia anguste siliquiformia valde variabilia, 35-65  $\mu$  longa, 5-9  $\mu$  crassa, basi angustata, 2.5-4  $\mu$  crassa, apices hypharum terminantia vel singula vel bina vel post hyphae ramificationem sympodialeam quasilateralia; zoosporis ovoideis vel subcylindricis, 7-9  $\mu$  longis, 4.5-5.0  $\mu$  latis postice cilio quam somate duplo vel triplo longiore praeditis; oogonium primum terminale vel post ramificationem hyphae sympodialeam saepe quasilaterale, clavatum vel obpyriforme, apice rotundatum basi anguste cylindricum, 15-17  $\mu$  longum, 8-10  $\mu$  crassum basi ad diametrum 2-3  $\mu$  angustatum, intus maturitate globulos magnos refractivos includens; antheridia hypogena, saepe plura basipetaliter producta, singula ex segmento hyphae hypooogonialis atque protrusione rostrata laterali 8-10  $\mu$  longa, 4-5  $\mu$  lata, constantia; antherozooideis plerumque binis, amoeboideis, postice uniciliatis, ovoideis si natanibus, ca. 5  $\mu$  longis, 3  $\mu$  latis, per orificiem ad rostri apicem

<sup>1</sup> I am indebted to Prof. H. H. Bartlett for preparing the Latin description of the species.



emergentibus; ova inseminata late ovoidea vel fere sphaerica, 10–13  $\mu$  longa, 8–10  $\mu$  lata, postice uniciliata, natantia, intus guttulata, globulis magnis refractivis includentia; oosporis in aqua liberis sphaericis, 8–11  $\mu$  dia., etiamque guttulis, membrana paulum incrassata pallide brunnea laevia, germination hucusque ignota.

In agro Oryzae prope viam ex "Port au Spain" ad "Pitch Lake," Trinidad, B. W. I., legit William Randolph Taylor. Coll. April 18, 1939.—F. K. SPARROW, JR.

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<sup>1</sup> This index was prepared by G. M. Miller.

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